OCS Report
MMS 2002-032

Oil-Spill Risk Analysis: Gulf of Mexico Outer Continental Shelf (OCS) Lease Sales, Central Planning Area and Western Planning Area, 2003-2007, and Gulfwide OCS Program, 2003-2042

U.S. Department of the Interior
MMS Minerals Management Service
Environmental Division

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Introduction

The Federal Government plans to offer U.S. Outer Continental Shelf (OCS) lands in the Central and Western Planning Areas of the Gulf of Mexico (GOM) for oil and gas leasing (Fig. 1). Because oil spills may occur from activities associated with offshore oil exploration, production, and transportation resulting from these lease sales, the Minerals Management Service (MMS) conducts a formal oil-spill risk analysis (OSRA) to support the environmental impact statement (EIS) completed prior to conducting the proposed leasing of these areas. This report summarizes results of that analysis, the objective of which was to estimate the risk of oil-spill contact to sensitive offshore and onshore environmental resources and socioeconomic features from oil spills accidentally occurring from the OCS activities.

The occurrence of oil spills is fundamentally a matter of probability. There is no certainty regarding the amount of oil that would be produced, or the size or likelihood of a spill that would occur, during the estimated life of a given lease sale. Neither can the winds and ocean currents that transport oil spills be known for certain. A probabilistic event such as an oil-spill occurrence or oil-spill contact to an environmentally sensitive area cannot be predicted, only an estimate of its likelihood (its probability) can be quantified.

The OSRA was conducted in three parts corresponding to different aspects of the overall problem.

1. The probability of oil-spill occurrence, which is based on spill rates derived from historic data and on estimated volumes of oil produced and transported.
2. The trajectories of oil spills from hypothetical spill locations to locations of various environmental resources, which are simulated using the OSRA Model (Smith et al., 1982).
3. The combination of results of the first two to estimate the overall oil-spill risk if there is oil development.

This report is available from the MMS's Internet site (*http://www.mms.gov*).

Framework of the Analysis

The Proposed Actions and the Gulfwide OCS Program

The proposed Federal actions addressed in this report are oil and gas lease sales in the Central Planning Area (CPA) and Western Planning Area (WPA) of the Gulf of Mexico OCS (Fig. 1). Under the Proposed Final Outer Continental Shelf Oil and Gas Leasing Program: 2002-2007 (USDOI, MMS, 2002a) (5-Year Program), two sales would be held each year—one in the CPA and one in the WPA. The proposed CPA lease sales are Sale 185 in 2003, Sale 190 in 2004, Sale 194 in 2005, Sale 198 in 2006, and Sale 201 in 2007; the proposed WPA lease sales are Sale 187 in 2003, Sale 192 in 2004, Sale 196 in 2005, and Sale 200 in 2006 (USDOI, MMS, 2002b). The purpose of the proposed Federal actions is to offer for lease those areas that may contain economically recoverable oil and natural gas resources. The Gulfwide OCS Program comprises all future operations that will occur over a 40-year time period (2003-

2042) from proposed, existing, and future leases in all three GOM planning areas: Western, Central, and Eastern. The development scenario assumes that the oil produced in the lease areas will be transported to shore predominantly by pipelines, with a small quantity transported by barge/shuttle tankers (LaBelle, 2001).

The proposed actions analyzed in this report are one "typical" CPA lease sale and one "typical" WPA lease sale. A set of ranges for resource estimates and projected exploration and development activities developed for each "typical" proposed action was used to analyze spill risk. The analyses of oil-spill risk for these "typical" proposed actions are expected to be "typical" of any of the other proposed CPA or WPA sales scheduled in the 5-Year Program. In other words, each of the proposed sales in the 5-Year Program is expected to be within the ranges used for the analyzed "typical" proposed action in the corresponding planning area.

Domain/Study Areas

The domain (shown in Fig.1) defines the geographic boundaries that encompass the environmental resources at risk from a hypothetical oil spill from OCS operations in the lease areas. Although few hypothetical oil spills were likely to extend beyond the borders of the domain within 30 days after release (the maximum elapsed time considered), we have tracked and tabulated spills that would travel beyond the open-ocean boundaries. These spills could contact land or other environmental resources outside the domain.

The two study areas (shown in Fig. 1) are the areas of the CPA and WPA that encompass the offshore waters within the Gulf of Mexico (beginning 3 miles offshore Louisiana, Mississippi, and Alabama; and 3 leagues offshore Texas) and extend seaward to the limits of the Exclusive Economic Zone. (Note that although the Eastern Planning Area is depicted in Fig. 1, it was not analyzed in this report.)

The study areas were divided into offshore subareas based upon ranges in water depth. These water depth ranges reflect the technological requirements and related physical and economic impacts as a consequence of the oil and gas potential, exploration and development activities, and lease terms unique to each water-depth range.

A cluster analysis (Everitt, 1993) is used to further divide the subareas into 46 hypothetical spill sites. Cluster analysis is a multivariate technique that groups entities based on similar characteristics. In this case, the MMS used the probability of contact to shoreline segments to identify offshore areas that showed similar risk based on similarity in patterns of trajectories. The study area and the hypothetical spill sites (launch subareas), which are used to represent oil-spill risks from drilling and production at a fixed facility, are shown in Figures 2a and 2b.

To account for the risk of spills occurring from the transportation of oil to shore via pipeline, generalized pipeline corridors originating within each of the offshore cluster areas and terminating at existing major oil pipeline shore bases were identified. These pipeline corridors represent the complex matrix of pipeline systems existing offshore that are likely to be used in support of each proposed action. The oil volume estimated to be produced within each cluster area was proportioned among likely pipeline corridor routes, representing the transportation of the oil beginning within a cluster area and terminating at State/Federal boundaries proximate to known pipeline shore bases.

Hypothetical Spill Locations

The OSRA Model initiated hypothetical oil spills uniformly in space and time from within each study area, as shown in Figures 2a and 2b. At $1/10^{o}$ intervals in the north-south direction (about 11 km) and $1/10^{o}$ intervals in the east-west direction (about 10 km), the model launched an oil spill every 1.0 day. At this resolution, there were 3,135 total launch points in space, and a total of 3,240 oil-spill trajectories were launched from each spatial grid point over a period of 9 years. The spatial resolution of the spill simulations was well within the spatial resolution of the input data, and the interval of time between releases was sufficiently short to sample weather-scale changes in the input winds (Price et al., 2002).

The sensitivity tests on the OSRA Model (Price et al., 2002) indicated that, statistically, the above-mentioned spatial resolution ($1/10^{o}$ by $1/10^{o}$) and time resolution (1.0 day) are sufficient to represent the spatial and time variations of the particle trajectories in the area.

Estimated Volume of Oil Resources

For this analysis, both benefits and risks are functions of the volume of oil produced and are mutually dependent. For example, greater volumes of produced oil are associated with greater economic benefits as well as greater risks. If the benefits are evaluated by assuming production of a specific amount of oil, then the corresponding risks should be stated conditionally, such as "the risks are . . . , given that the volume is . . . ." Any statements about the likelihood of a particular volume of oil being developed also apply to the likelihood of the corresponding benefits and risks.

The resource estimates are presented for the following scenarios:

Proposed Action—the range of oil resources estimated to be leased, discovered, and produced over a 40-year time period as a result of a typical WPA or CPA lease sale, as found in the proposed 5-Year Program for 2002-2007.

OCS Program—the range of oil resources estimated to be leased, discovered, and produced as a result of prior lease sales, the proposed actions, and future lease sales that will occur during the life of a proposed action (40 years).

The range in oil resource projections used to develop the proposed actions and OCS Program scenarios are based on resource and reserves estimates as presented in the *2000 Assessment of Conventionally Recoverable Hydrocarbon Resources of the Gulf of Mexico and Atlantic Outer Continental Shelf as of January 1, 1999* (Lore et al., 2001), current industry information, and historical trends. The resource estimates for the proposed actions are based on two factors: (1) the conditional estimates of undiscovered, unleased, conventionally recoverable oil and gas resources in the proposed lease sale areas; and (2) estimates of the portion or percentage of these resources assumed to be leased, discovered, developed, and produced as a result of the proposed actions. The estimates of undiscovered, unleased, conventionally recoverable oil and gas resources are based upon a comprehensive appraisal of the conventionally recoverable petroleum resources of the Nation as of January 1, 1999. Due to the inherent uncertainties associated with an assessment of undiscovered resources, probabilistic techniques were employed, and the results were reported as a range of values corresponding to different probabilities of occurrence. A thorough discussion of the methodologies employed and the results obtained in the assessment are presented in Lore et al. (2001). The estimates of the portion of the resources assumed to be leased, discovered, developed, and produced as a result of the proposed actions are based upon logical sequences of events that incorporate past experience, current conditions, and foreseeable development strategies. A wealth of historical data and information derived from over 50 years of oil and gas exploration, development, and production activities were used extensively by MMS. The undiscovered, unleased, conventionally recoverable resource estimates for the proposed actions are expressed as ranges, from low to high. The range reflects a range of projected economic valuations of the produced oil and gas. The "low" end of the range is based on an economic case of $18 per barrel of oil. The "high" estimate is based on an economic case of $30 per barrel of oil.

The projected life of all exploration, development, production, and abandonment activities that result from a typical proposed lease sale is assumed to be 40 years. This is based on averages for the amount of time required for these activities for Gulf of Mexico leases. The projected oil production (in billion barrels [Bbbl]) for a typical proposed lease sale and the OCS Program are as follows:

Proposed Action		Estimated Production (Bbbl)	Analysis Period
Low Estimate:	Western GOM	0.136	40 years
	Central GOM	0.276	40 years
High Estimate:	Western GOM	0.262	40 years
	Central GOM	0.654	40 years

OCS Program		Estimated Production (Bbbl)	Analysis Period
Low Estimate:	Western GOM	3.35	40 years
	Central GOM	12.00	40 years
	Eastern GOM	0.14	40 years
	Gulfwide	15.49	40 years
High Estimate:	Western GOM	5.53	40 years
	Central GOM	16.52	40 years
	Eastern GOM	0.37	40 years
	Gulfwide	22.42	40 years

Environmental Resources

The environmental resources considered in this analysis were selected by MMS analysts in the Gulf of Mexico OCS Region after consultation with the U.S. Fish and Wildlife Service. The analysts used geographic digital information on the biological, physical, and socioeconomic resources that could be exposed to contact from OCS oil spills to create maps of resource locations vulnerable to oil-spill impact. These maps (Figs. 3 through 31) depict locations that were analyzed by the OSRA Model, representing either the locations of onshore environmental resource habitats or the surface waters overlying or surrounding offshore environmental features. The MMS used data derived from the Central Offshore Resource Information System (CORIS) and other databases. The CORIS data were developed and supported by State and Federal Agencies and the oil industry operating along the Gulf coast.

All onshore, coastal environmental resource locations were represented by one or more partitions of the coastline, herein called land. The study area coastline was partitioned into 162 equidistant land segments of approximately 10-mile (16-km) length. The partitions were formed by creating straight lines between two points projected onto the coast; therefore, the actual miles of shoreline represented by each land segment may be greater than 10 miles, depending upon the complexity of the coastal area.

In addition, the State offshore waters were included as environmental resources. Texas and Florida State offshore waters are extended 3 marine leagues (1 marine league = 1,8228.3 ft) seaward from the baseline from which the breadth of the territorial sea is measured. Louisiana State offshore waters is extended 3 imperial nautical miles (1 imperial nautical mile = 6,080 ft) seaward of the baseline from which the breadth of the territorial sea is measured. Mississippi and Alabama State offshore waters are extended 3 nautical miles (1 nautical mile = 6,076 ft) seaward of the baseline from which the breadth of the territorial sea is measured. In order to tabulate the number of spills traveling beyond the study area, the borders of the domain were divided into four boundary segments.

The environmental resources and socioeconomic features examined in this OSRA and the figures illustrating their locations are shown below. Periods of habitat or beach use are identified in parentheses.

Listing of Environmental Resources	Figure
6 Bird Habitats	
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Gulls, Terns, And Charadriid Allies Habitat	8
Raptor Bird Habitat	9
Charadriid Shorebird Habitat	10
Wading Bird Habitat	11
Waterfowl Habitat	12

Listing of Environmental Resources	Figure
5 Endangered Bird Habitats	
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LA East Marine Mammal Habitat	28
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AL Marine Mammal Habitat	29
FL Panhandle Marine Mammal Habitat	25
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9 Manatee Habitats	
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FL Big Bend Manatee Areas (Apr-Nov)	31
FL Big Bend Manatee Areas (Dec-Mar)	31
FL Southwest Manatee Areas (Apr-Nov)	30
FL Southwest Manatee Areas (Dec-Mar)	30
FL Ten Thousand Islands Manatee Areas (Apr-Nov)	31
FL Ten Thousand Islands Manatee Areas (Dec-Mar)	31
LA/MS/AL Manatee Areas (Apr-Nov)	31

Listing of Environmental Resources — Figure

Listing of Environmental Resources	Figure
Counties/Parishes (Continued)	
Vermilion, LA	24
Iberia, LA	23
St. Mary, LA	24
Terrebonne, LA	23
Lafourche, LA	24
Jefferson, LA	23
Plaquemines, LA	24
St. Bernard, LA	23
Hancock & Harrison, MS	24
Jackson, MS	23
Mobile, AL	24
Baldwin, AL	23
Escambia, FL	24
Santa Rosa, FL	23
Okaloosa, FL	24
Walton, FL	23
Bay, FL	24
Gulf, FL	23
Franklin, FL	24
Wakulla, FL	23
Jefferson, FL	24
Taylor, FL	23
Dixie, FL	24
Levy, FL	23
Citrus, FL	24
Hernando, FL	23
Pasco, FL	24
Pinellas, FL	23
Hillsborough, FL	24
Manatee, FL	23
Sarasota, FL	24
Charlotte, FL	23
Lee, FL	24
Collier, FL	23
Monroe, FL	24
8 Offshore State Waters	
Mexican Waters	6
TX State Offshore Waters	3
LA (Eastern) State Offshore Waters	4
LA (Western) State Offshore Waters	5
MS State Offshore Waters	6
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Listing of Environmental Resources	Figure
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Stetson Bank	4
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Oil-Spill Risk Analysis

The OSRA was conducted in three parts corresponding to different aspects of the overall problem: (1) the probability of oil-spill occurrence, (2) the trajectories of oil spills from hypothetical spill locations to various environmental resources, and (3) a combination of the first two to estimate the overall oil-spill risk of combined occurrence and contact if there is oil development. The second and third parts were completed for the analysis of spills from the proposed actions.

Risk analyses may be characterized as "hazard-based" or "risk-based." A hazard-based analysis examines possible events regardless of their low (or high) likelihood. For example, a potential impact would not lose significance because the risk has been reduced due to an increase in the level of control, such as engineering standards. A risk-based analysis, on the other hand, does take into account the likelihood of the event occurring or the measures that can be taken to mitigate against its potential impacts.

This OSRA is designed for use as a risk-based assessment. Therefore, the likelihood of oil spills ($\geq$ 1,000 bbl in size) occurring on the OCS plays an integral role in the analysis. In addition to the estimated chance of spills occurring, the analysis entails an extensive oil-spill trajectory model. Results from the trajectory analysis provide input to the final product by estimating where spills might travel on the ocean's surface and what resources might be contacted.

Results from the OSRA are, therefore, expressed as the combined probability of spills both occurring and contacting modeled offshore and coastal environmental resource locations. Note that the analysis estimates spill contacts, not impacts. Further measures that should be evaluated to determine impacts, such as the natural weathering of oil spills and cleanup activities, are not directly factored into the analysis but should be added to the interpretation of its results.

Probability of Oil Spills Occurring

The probability of oil spills occurring assumes that spills occur independently of each other as a Poisson process. The Poisson process is a statistical distribution commonly used to model random events. The probability of oil spills occurring is based on spill rates derived from past OCS platform and OCS pipeline experience and all tanker experience in U.S. waters, and depends on the volume of oil produced and transported. All types of accidental spills greater than or equal to 1,000 bbl were considered in this analysis. These spills include those from well blowouts, other accidents that occur on platforms, and during transportation of oil to shore. These spills were classified as either platform, pipeline, or tanker spills. This classification allows the analyst to compare the risks from each spill source between a proposed action and any alternatives.

Anderson and LaBelle (1994, 2000) examined oil-spill occurrence rates applicable to the OCS. Their results, adjusted for recent experience and based upon more complete databases than were available for earlier analyses (Anderson and LaBelle, 1990; Lanfear and Amstutz, 1983), indicated some significant changes in the spill rates for platforms and pipelines. In addition, they developed estimated occurrence rates for tanker spills that have occurred in U.S. waters. This report uses the updated spill occurrence rates.

Spill rates are expressed as number of spills per billion barrels (spills/Bbbl), defined as 10^9 bbl, of oil produced or transported. Only spills greater than or equal to 1,000 bbl are addressed because smaller spills may not persist long enough to be simulated by trajectory modeling. Another consideration is that these large spills are likely to be identified and reported; therefore, these records are more comprehensive than those of smaller spills. (Smaller spills are addressed in the EIS for each proposed action without the use of trajectory modeling.)

Two basic criteria were used in selecting volume of oil handled as the risk exposure variable: (1) the exposure variable should be simple to define, and (2) it should be a quantity that can be estimated. The volume of oil produced or transported was the chosen exposure variable primarily for the following reasons: historic volumes of oil produced and transported are well documented; using these volumes makes the calculation of the estimated oil-spill occurrence rate simple—the ratio of the number of historic spills to the volume of oil produced or transported; and future volumes of oil production and transportation are routinely estimated. Estimates of volume to be developed for a proposed action and the Gulfwide OCS Program, which were prepared by analysts in the MMS Resource Evaluation Division, Gulf of Mexico Regional Office, are derived from the assessment of oil resources by using comprehensive geological and geophysical databases and related models. In addition, the MMS analysts estimate other exposure variables, such as number of platforms and tanker trips, as a function of the volume of oil estimated to be produced or transported.

Anderson and LaBelle (1994, 2000) analyzed platform and pipeline spills in Federal waters that occurred from OCS oil and gas development from 1964 through 1999 and crude oil tanker spills that occurred in U.S. waters from 1974 through 1999. In these analyses, every spill record was examined and verified to the furthest extent possible. Each spill was classified for size, product spilled, and spill source according to its applicability to the analysis.

For this OSRA study, the analysis used the following spill rates based on a 15-year period (1985-1999), as found in Anderson and LaBelle (2000) as best representing current technology. The rates are based on number of spills per billion barrels of oil (spills/Bbbl) produced at OCS platforms or transported by OCS pipelines or OCS tankers.

Oil Spill Rates Based on 1985-1999 Data (Anderson and LaBelle, 2000)

Spill Source	**No. of Spills ≥ 1,000 bbl**	**No. of Spills ≥ 10,000 bbl**
OCS Platforms	0.13 spills/Bbbl	0.05 spills/Bbbl
OCS Pipelines	1.38 spills/Bbbl	0.34 spills/Bbbl
OCS Tankers	0.72 spills/Bbbl	0.25 spills/Bbbl

Using Bayesian techniques, Devanney and Stewart (1974) showed that the probability of *n* oil-spill contacts can be described by a negative binomial distribution. Smith et al. (1982), however, noted that when actual exposure is much less than historical exposure, as is the case here, the negative binomial distribution can be approximated by a Poisson distribution. The Poisson distribution has a significant advantage in calculations because it is defined by only one parameter, the assumed number of spills. If $p(n,i)$ is the probability of exactly *n* contacts to environmental resource *i*, then:

$$p(n,i) = \frac{\lambda_i^{\,n} \cdot e^{-\lambda i}}{n!}$$

where *n* is the specific number of spills (0, 1, 2, ..., *n*), *e* is the base of the natural logarithm, and λ is the parameter of the Poisson distribution. For oil spills, the Poisson parameter (λ) is equal to the spill rate multiplied by the volume of oil to be produced or transported. The spill rate has dimensions of number of spills/Bbbl, and the volume is expressed in Bbbl. Therefore, λ denotes the mean number of spills estimated to occur as a result of production or transportation of a specific volume of oil.

Oil-spill occurrence estimates for spills greater than or equal to 1,000 bbl were calculated for production and transportation of oil during the 40-year analysis period associated with the proposed actions in the WPA, CPA, and the Gulfwide OCS Program (2003-2042). These probabilities are based on the volume of oil estimated to be found, produced, and transported over the life of a typical lease sale and on the rates that have been calculated for oil spills from OCS platforms, pipelines, and tankers by Anderson and LaBelle (2000). The probabilities of one or more oil spills greater than or equal to 1,000 bbl occurring as a result of OCS exploration, development, and production and transportation resulting from a typical lease sale or the OCS Program are found in Table 1a. The probabilities for spills greater than or equal to 10,000 bbl are shown in Table 1b.

Oil-Spill Trajectory Simulations

The OSRA Model, originally developed by Smith et al. (1982) and enhanced by MMS over the years (LaBelle and Anderson, 1985; Price et al., 2002), simulates oil-spill transport using realistic data fields of winds and ocean currents in the GOM. An oil spill on the ocean surface moves around by the complex surface ocean currents exerting a shear force on the spilled oil from below. In addition, the prevailing wind exerts an additional shear force on the spill from above, and the combination of the two forces causes the transportation of the oil spill away from its initial spill location. In the OSRA Model, the velocity of a hypothetical oil spill is the linear superposition of the surface ocean current and the wind drift caused by the winds. The model calculates the movement of hypothetical spills by successively integrating time sequences of two spatially gridded input fields: the surface ocean currents and the sea-level winds, both of which were generated by other computer models using many observations of relevant physical parameters. In this fashion, the OSRA Model generates time sequences of hypothetical oil-spill locations–essentially, oil-spill trajectories.

At each successive time step, the OSRA Model compares the location of the hypothetical spills against the geographic boundaries of shoreline and designated offshore environmental resources. The model counts the occurrences of oil-spill contact to these areas during the time periods that the habitat is known to be used by the resource. Finally, the frequencies of oil-spill contact are computed for designated oil-spill travel times (e.g., 3, 10, or 30 days) by dividing the total number of oil-spill contacts by the total number of hypothetical spills initiated in the model from a given hypothetical spill location. The frequencies of oil-spill contact are the model-estimated probabilities of oil-spill contact. For example, the model might count 100 oil-spill contacts to the Bald Eagle Habitat within 10 days of oil-spill travel time out of 2,000 hypothetical oil spills released at a particular location within the lease area. The estimated probability of oil-spill contact would be 5 percent (100/2,000). The 2,000 releases would be made at regular intervals over 9 years of model time (the time span of the ocean current and wind data from January 1, 1986, to December 31, 1994). The 10-day contacts would be those hypothetical spills that contacted the Bald Eagle Habitat within 10 days of their releases. The OSRA Model output provides the estimated probabilities of contact to all identified offshore environmental resources and segments of shoreline from locations chosen to represent hypothetical oil spills from oil production and transportation facilities, at several selected oil-spill travel times.

There are factors not explicitly considered by the OSRA Model that can affect the transport of spilled oil as well as the dimensions, volume, and nature of the oil spills contacting environmental resources or the shoreline. These include possible cleanup operations, chemical composition or biological weathering of oil spills, or the spreading and splitting of oil spills. The OSRA analysts have chosen to take a more environmentally conservative approach by presuming persistence of spilled oil over the selected duration of time of the trajectories.

In the trajectory simulation portion of the OSRA Model, many hypothetical oil-spill trajectories are produced by numerically integrating a temporally and spatially varying ocean current field and superposing on that an empirical wind-induced drift of the hypothetical oil spills (Samuels et al., 1982). Collectively, the trajectories represent a statistical ensemble of simulated oil-spill displacements produced by a field of winds derived from observations and numerically derived ocean currents. The winds and currents are assumed to be statistically similar to those that will occur in the Gulf during future offshore activities. In other words, the oil-spill risk analysts assume that the frequency of strong wind events in the wind field is the same as what will occur during future offshore activities. By inference, the frequencies of contact by the simulated oil spills are the same as what could occur from actual oil spills during future offshore activities.

The other portion of the OSRA Model tabulates the contacts by the simulated oil spills. The model contains the geographical boundaries of a variety of identified environmental features. The shoreline segments proximate to their locations identify onshore resources. Offshore resources are identified by the area of surface waters overlying their locations. At every integration time step, the OSRA Model monitors the locations of the simulated spills and counts the number of oil-spill contacts to segments of shoreline and the locations of onshore and offshore environmental resources. A contact to shore will stop the trajectory of an oil spill; no re-washing is assumed in this model. However, contacts to the transparent (non-land) offshore resources will not stop the respective trajectories. After specified periods of time, the OSRA Model will divide the total number of contacts to the coastline segments and the environmental resources by the total number of simulated oil spills from a given geographic location. These ratios are the estimated probabilities of oil-spill contact from offshore activities at that geographic location, assuming spill occurrence.

The ocean currents used are numerically computed from an ocean circulation model of the GOM driven by analyzed meteorological forces (the near surface winds and the total heat fluxes) and observed river inflow into the GOM (Herring et al., 1999). The model used is the Princeton-Dynalysis Ocean Model (PDOM), an enhanced version of the earlier constructed Mellor-Blumberg Model. It is a three-dimensional, time-dependent, primitive equation model using orthogonal curvilinear coordinates in the horizontal and a topographically conformal coordinate in the vertical. The use of these coordinates allows for a realistic coastline and bottom topography, including a sloping shelf, to be represented in the model simulation. The model incorporates the Mellor-Yamada turbulence closure model to provide a parameterization of the vertical mixing process through the water column.

The prognostic variables of the model are velocity, temperature, salinity, turbulence kinetic energy, and turbulence macroscale. The momentum equations are nonlinear and incorporate a variable Coriolis parameter. Prognostic equations governing the thermodynamic quantities (temperature and salinity) account for water mass variations brought about by highly time-dependent coastal upwelling processes. The processes responsible for eddy production, movement, and eventual dissipation are also included in the model physics. Other computed variables include density, vertical eddy viscosity, and vertical eddy diffusivity.

A 9-year simulation was performed on the computational grid shown in Figure 32. The PDOM was driven by the European Center for Medium-Range Weather Forecasts (ECMWF) analyzed winds and heat fluxes over the 9-year period, 1986 through 1994. Three-hourly surface currents were then computed for input into the OSRA Model along with the concurrent ECMWF wind field. The OSRA Model used the same ECMWF wind field to calculate the empirical wind drift of the simulated spills.

The PDOM was extensively skill-assessed with many observations from the GOM (Herring et al., 1999). Among the observations was a large set of long-lived, surface drifters. Under the direction of Peter Niiler and Russ Davis of Scripps Institution of Oceanography (La Jolla, California), approximately 340 drifting buoys were deployed from aircraft and three production platforms in a repeated array located southeast of Galveston, Texas (Fig. 33). The investigation was called SCULP (Surface Current and Lagrangian-drift Program). Weekly deployments were made from mid-October 1993 running through January 1994, followed by monthly deployments through September 1994 (Herring et al., 1999).

This extensive set of Lagrangian observations affords a rigorous test of the model's ability to reproduce ocean transport as well as prominent features of the Gulf such as the Loop Current and strong mesoscale eddies, which are easily observed from satellite-borne instrumentation. With these observations and other current measurements from moored current meters, a good determination of the model's veracity was made. The PDOM did an excellent job in reproducing the characteristics of the GOM surface currents both on and off the continental shelf. However, since the model was not run in data assimilation mode, the resultant field of surface currents was not an exact reproduction of the currents that actually occurred during the 9 years of the ECMWF wind field. However, the surface current field manifests all the dominant structures in time and space as the observed currents and is, therefore, quite usable in the statistical estimation of future spill risk that the OSRA Model makes.

Trajectories of hypothetical spills were initiated every 1.0 day from each of the 3,135 launch points in space–3,240 trajectories per launch point over the 9-year simulation period. The chosen number of trajectories per site (3,240) was small enough to be computationally practical and large enough to reduce the random sampling error to an insignificant level. Also, the weather-scale changes in the winds are at least minimally sampled with simulated spills started every 1.0 day.

The OSRA Model integrates the spill velocities (a linear superposition of surface ocean currents and empirical wind drift) by forward stepping in time to produce the spill trajectories. The time step selected was 30 minutes to fully utilize the spatial resolution of the ocean current field and to achieve a stable set of trajectories. The velocity field was bilinearly interpolated from the 3-hourly grid to get velocities at 30-minute intervals. Smaller time steps did not produce significant differences in the simulated trajectories after 30 model days, so the 30-minute time step was chosen for this analysis. Price et al. (2002) summarized the latest improvement on the OSRA Model and the model sensitivity tests.

Conditional Probabilities of Contact

The probability that an oil spill will contact a specific environmental resource within a given time of travel from a certain location or spill point is termed a *conditional probability*, the condition being that a spill is assumed to have occurred. Each trajectory was allowed to continue for as long as 30 days. However, if the hypothetical spill contacted shoreline sooner than 30 days after the start of the spill, the spill trajectory was terminated, and the contact was recorded.

The trajectories simulated by the model represent only hypothetical pathways of oil slicks; they do not involve any direct consideration of cleanup, dispersion, or weathering processes that could alter the quantity or properties of oil that might eventually contact the environmental resource locations. However, an implicit analysis of weathering and decay can be considered by choosing a travel time for the simulated oil spills when they contact environmental resource locations that represent the likely persistence of the oil slick on the water surface. The MMS performed an analysis of the likely weathering and cleanup of a typical offshore oil spill of 1,000 bbl or greater occurring under the proposed action scenarios (USDOI, MMS, 2002). The analysis of the slick's fate showed that a typical GOM oil slick of 1,000 bbl or greater, exposed to typical winds and currents, would not persist on the water surface beyond 10 days. Therefore, OSRA Model trajectories were analyzed only up to 10 days. Any spill contacts occurring on or before this elapsed time are reported in the probability tables. Conditional probabilities of contact with environmental resource locations and land segments within 10 days of travel time were calculated for each of the hypothetical spill sites by the model to serve as input into the final calculation of risk.

Combined Probabilities of Contact

A critical difference exists between the conditional probabilities and the combined probabilities calculated. Conditional probabilities depend only on the winds and currents in the study area. Combined probabilities, on the other hand, depend not only on the physical conditions, but also on the chance of spill occurrence, the estimated volume of oil to be produced or transported, and the oil transportation scenario. The combined probabilities for this analysis of the proposed action activities are presented in Tables 2-6.

In calculating the combined probabilities, those that represent probabilities of both oil-spill occurrence and contact, the following steps are performed:

1. For a set of n_t environmental resources and n_l launch points, the conditional probabilities can be represented in a matrix form. Let [C] be an $n_t \times n_l$ matrix, where each element $c_{i,j}$ is the probability that an oil spill will contact environmental resource *i*, given that a spill occurs at launch point *j*. Note that launch points can represent potential starting points of spills from production areas or transportation routes.

2. Spill occurrence can be represented by another matrix [S]. With n_l launch points and n_s production sites, the dimensions of [S] are $n_l \times n_s$. Let each element $s_{j,k}$ be the estimated

mean number of spills occurring at launch point j owing to production of a unit volume (1 Bbbl) of oil at site k. These spills can result from either production or transportation. The $s_{j,k}$ can be determined as a function of the volume of oil (spills/Bbbl). Each column of [S] corresponds to one production site and one transportation route. If alternative and mutually exclusive transportation routes are considered for the same production site, they can be represented by additional columns of [S], thus increasing n_s.

3. Matrix [U] is defined as

$$[U] = [C] \times [S]$$

Matrix [U]—which has dimensions $n_t \times n_s$—is termed the unit risk matrix. Each element $u_{i,k}$ corresponds to the estimated mean number of spills occurring and contacting environmental resource i, owing to the production of a unit volume (1 Bbbl) of oil at site k.

4. With [U], the mean contacts to each environmental resource are estimated, given a set of oil volumes at each site. Let [V] be a vector of dimension n_s where each element v_k corresponds to the volume of oil expected to be found at production site k. Then, if [L] is a vector of dimension n_t, where each element λ_i corresponds to the mean number of contacts to environmental resource i, the formula is

$$[L] = [U] \times [V]$$

Thus, estimates of the mean number of oil spills that are likely to occur and contact environmental resources (or land segments) can be calculated. (Note that as a statistical parameter, the mean number can assume a fractional value, even though fractions of oil spills have no physical meaning.)

Discussion

As one might expect, environmental resource locations closest to the spill sites had the greatest risk of contact. As the model run duration increases, more of the identified environmental resources and shoreline segments could have meaningful probabilities of contact ($\geq$0.5%). The longer transit times up to 10 days allowed by the model enable more hypothetical spills to reach the environmental resources and the shoreline from more distant spill locations. With increased travel time, the complex patterns of wind and ocean currents produce eddy-like motions of the oil spills and multiple opportunities for a spill to make contact with any given environmental resource or shoreline segment.

For instance, Table 2 provides the probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 bbl, and the number of spills (mean), of the estimated volume of oil produced from the proposed action in the Gulf of Mexico CPA that could occur and contact a certain offshore environmental resource within 10 days. Only two resources (the entire U.S. shoreline and Louisiana (Western) State Offshore Waters) have a probability of more than 10 percent of being contacted by the spilled oil, if there is an oil spill from the proposed action in the CPA.

It should be noted that the study area does not extend into the Atlantic Ocean, where oil spills in the Gulf might be transported via the exiting Loop Current. However, on average, less than 0.5 percent of the simulated spills made it across the northern or southern Florida Straits boundary within 30 days.

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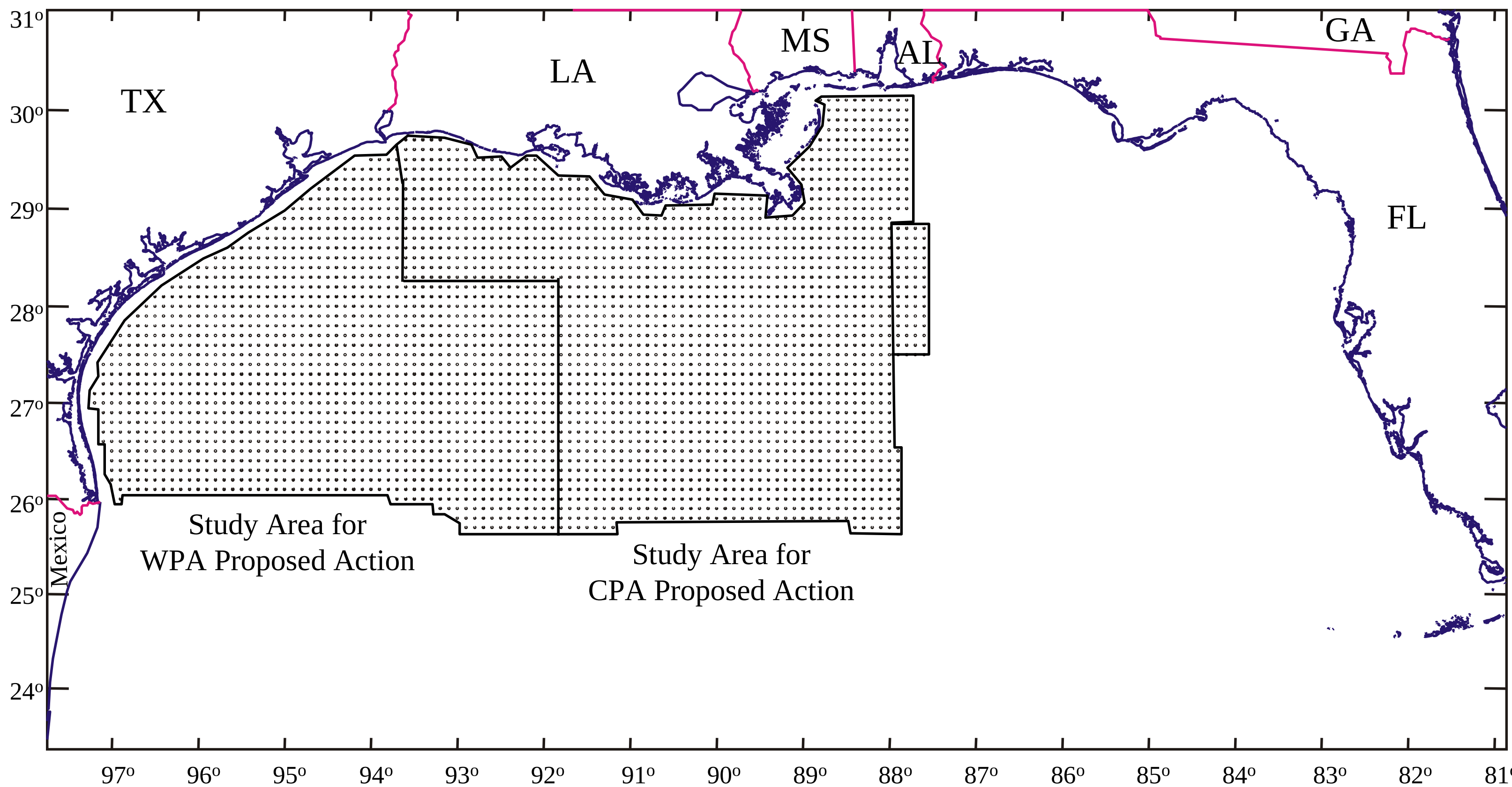

Figure 1. Domain and Study Areas for the Oil-Spill Risk Analysis. (The shaded areas represent the study area domain analyzed for the Gulfwide OCS Program.)

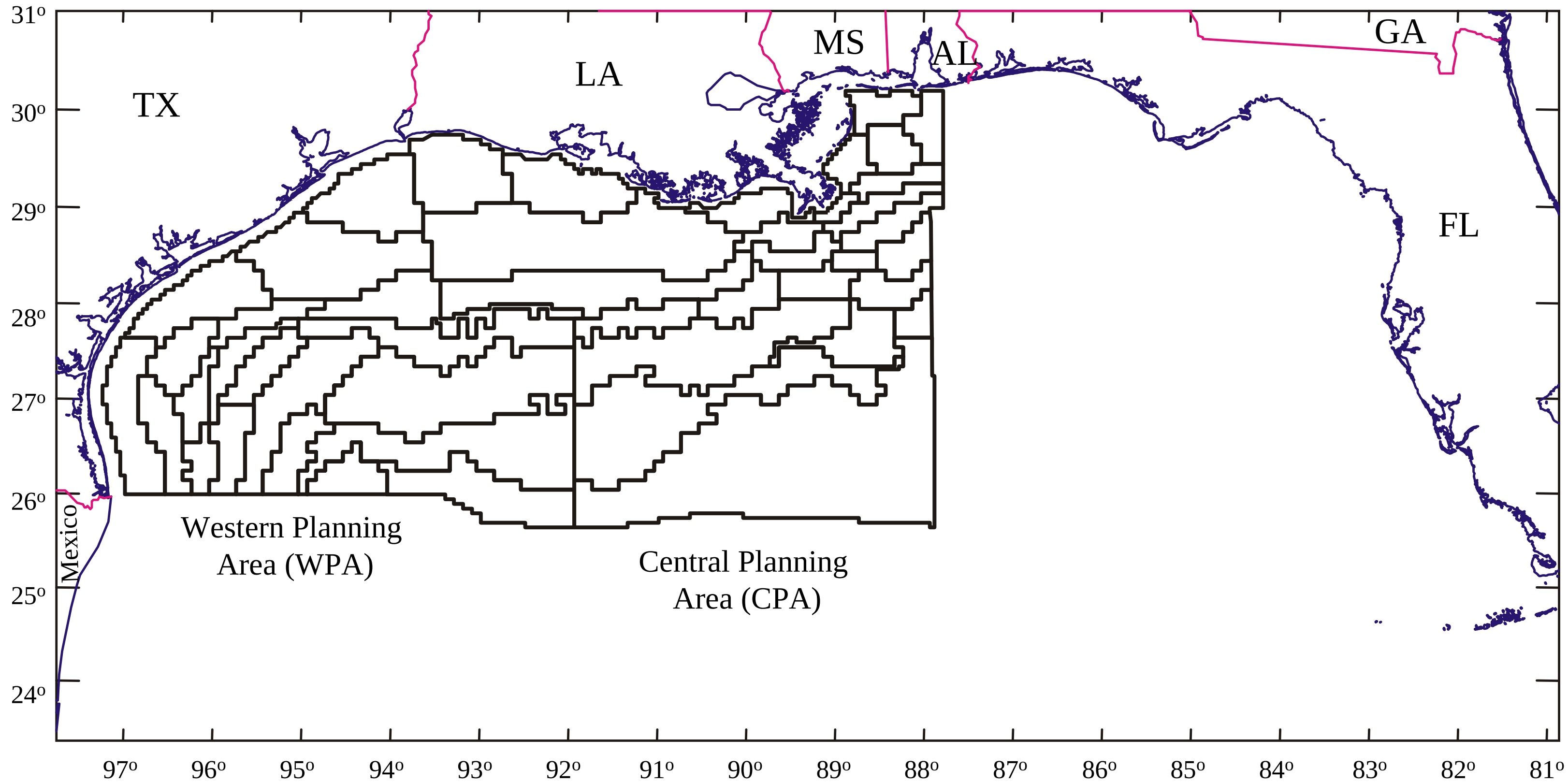

Figure 2a. Locations of 46 Cluster Subareas for Launching Hypothetical Spills. (Cluster subarea boundaries have been thickened for viewing purposes.)

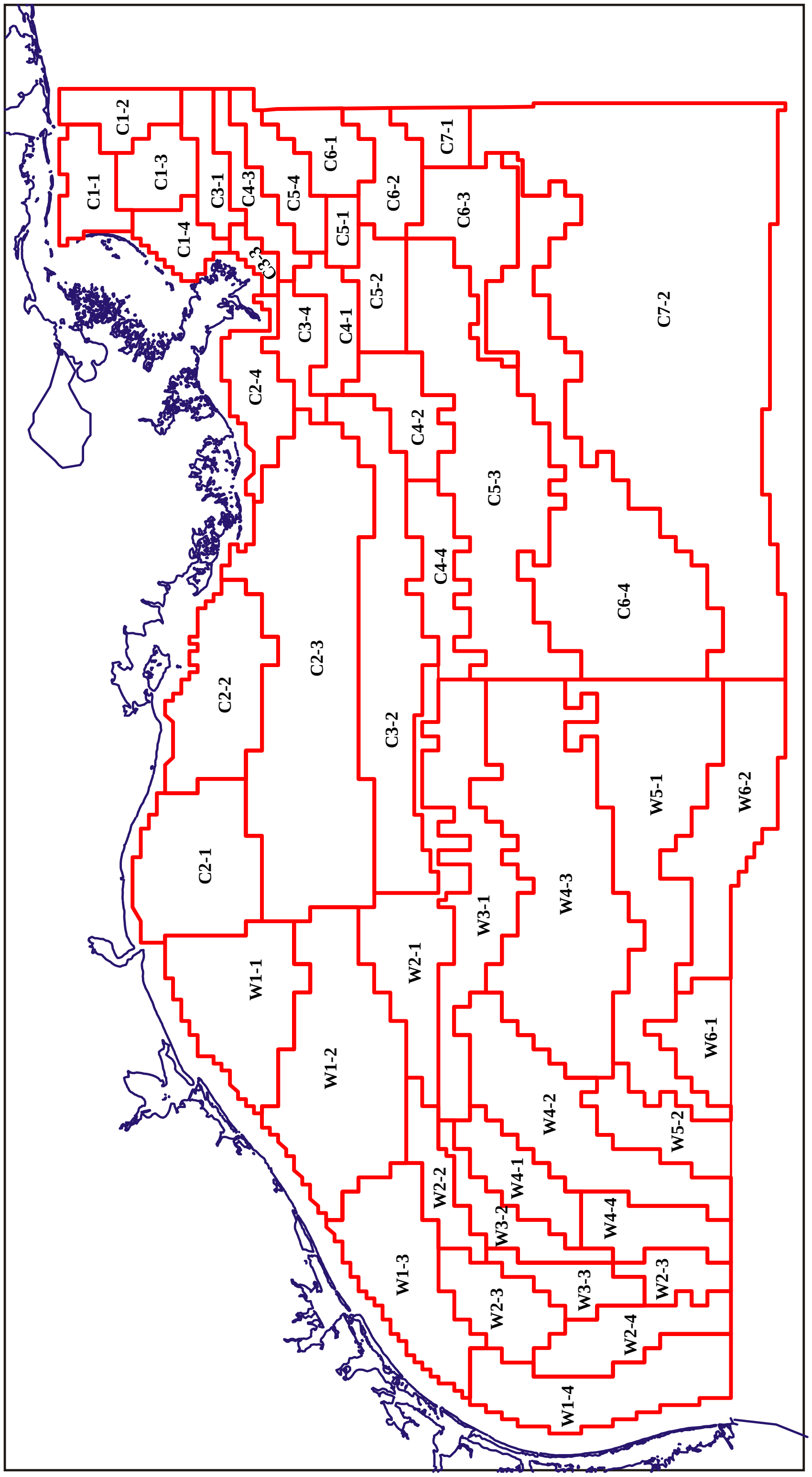

Figure 2b. Enlargement of Cluster Subareas. (Cluster subarea boundaries have been thickened for viewing purposes.)

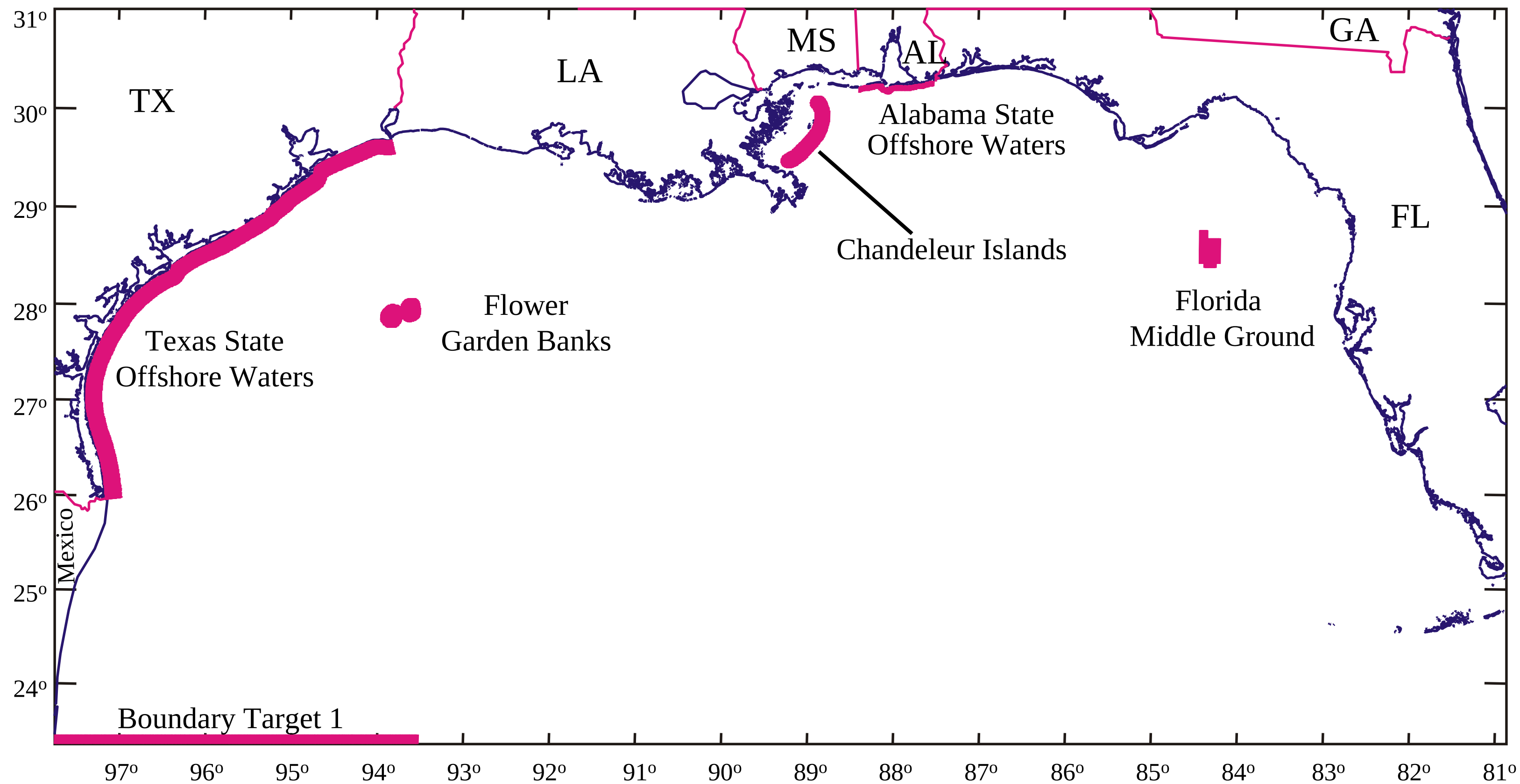

Figure 3. Locations of Texas State Offshore Waters, Flower Garden Banks, Alabama State Offshore Waters, Chandeleur Islands, Florida Middle Ground, and Boundary Target 1. (Shading is not to scale.)

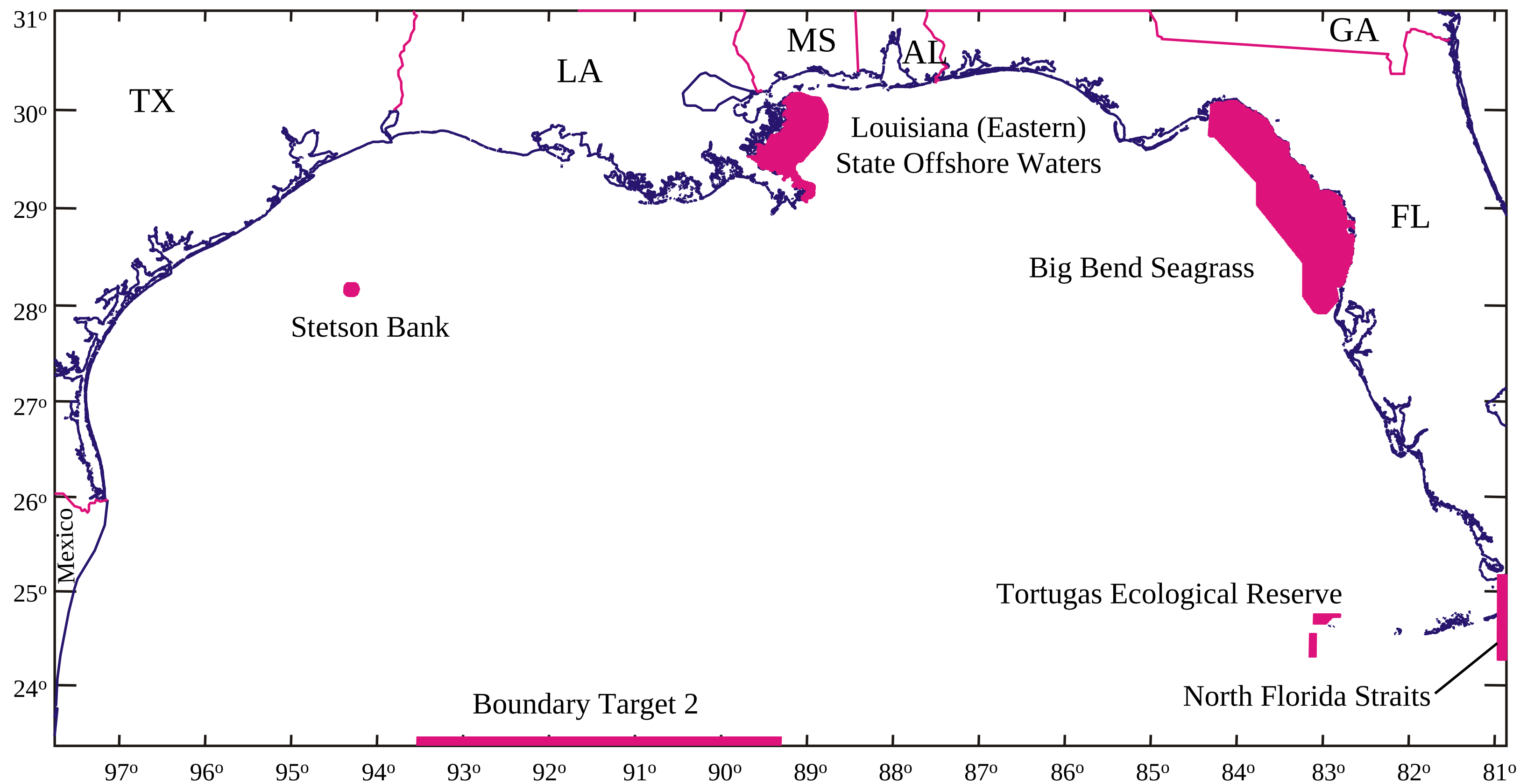

Figure 4. Locations of Stetson Bank, Louisiana (Eastern) State Offshore Waters, Big Bend Seagrass, Boundary Target 2, Tortugas Ecological Reserve, and North Florida Straits. (Shading is not to scale.)

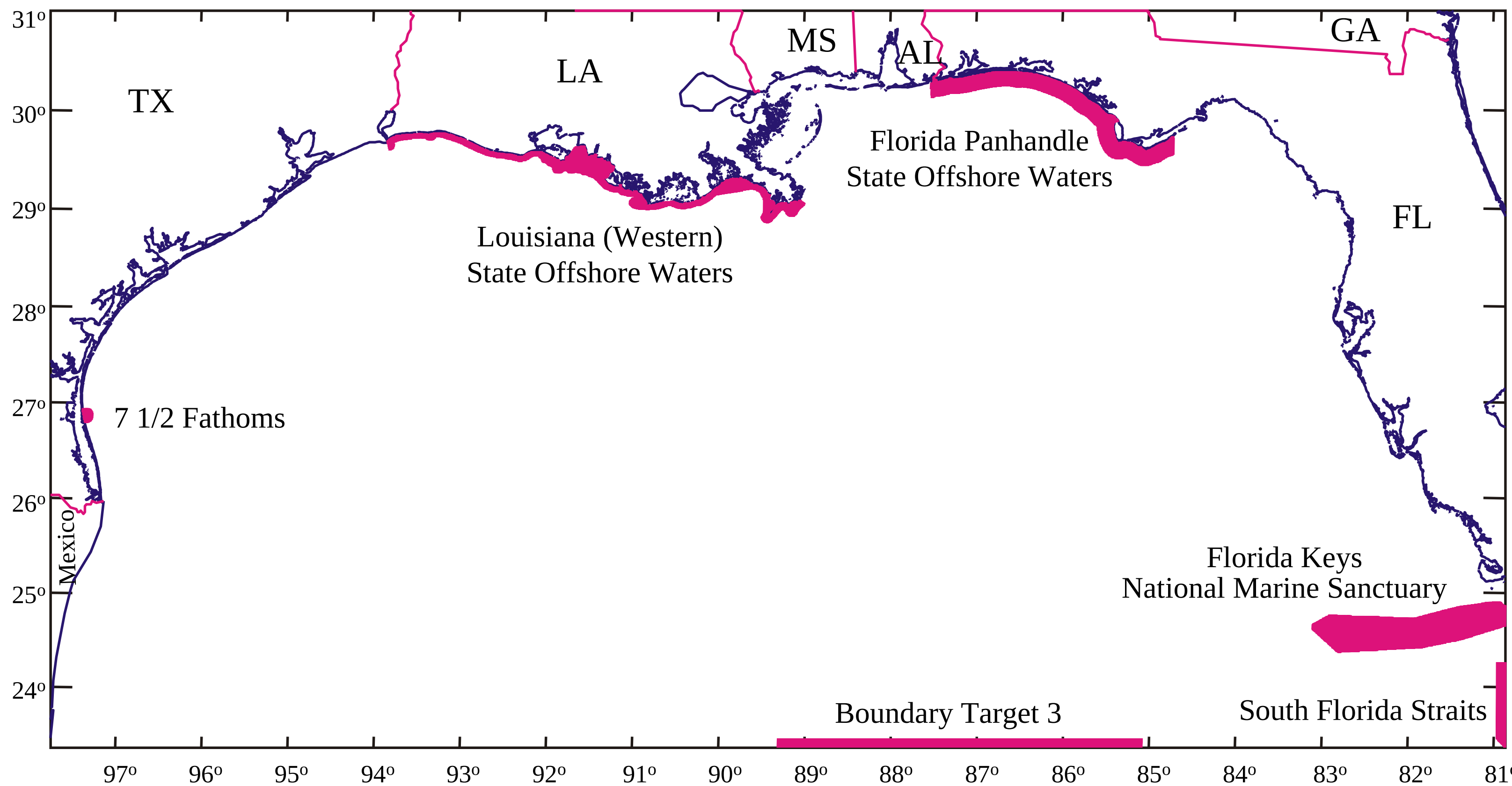

Figure 5. Locations of 7 1/2 Fathoms, Louisiana (Western) State Offshore Waters, Florida Panhandle State Offshore Waters, Florida Keys National Marine Sanctuary, Boundary Target 3, and South Florida Straits. (Shading is not to scale.)

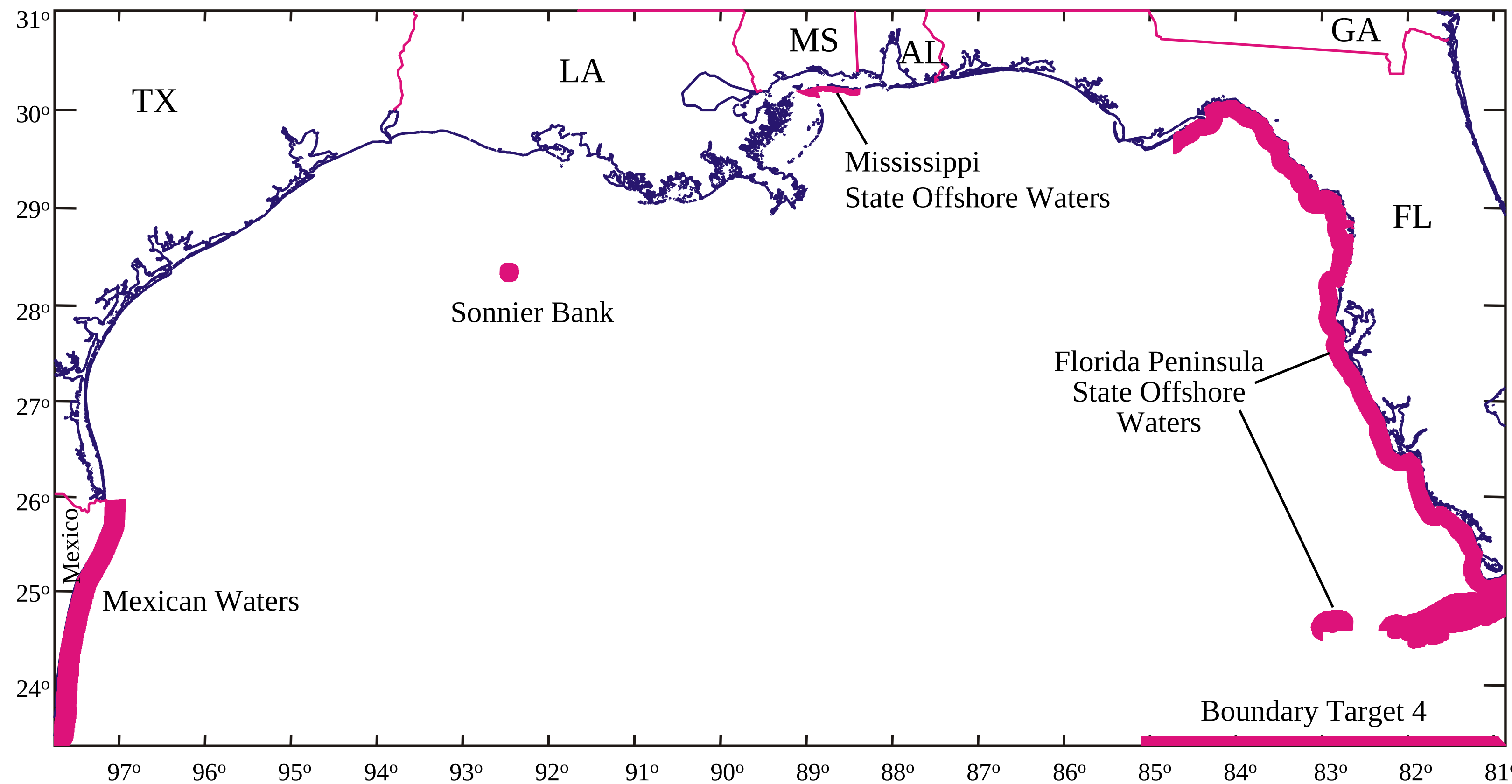

Figure 6. Locations of Mexican Waters, Sonnier Bank, Mississippi State Offshore Waters, Florida Peninsula State Offshore Waters, and Boundary Target 4. (Shading is not to scale.)

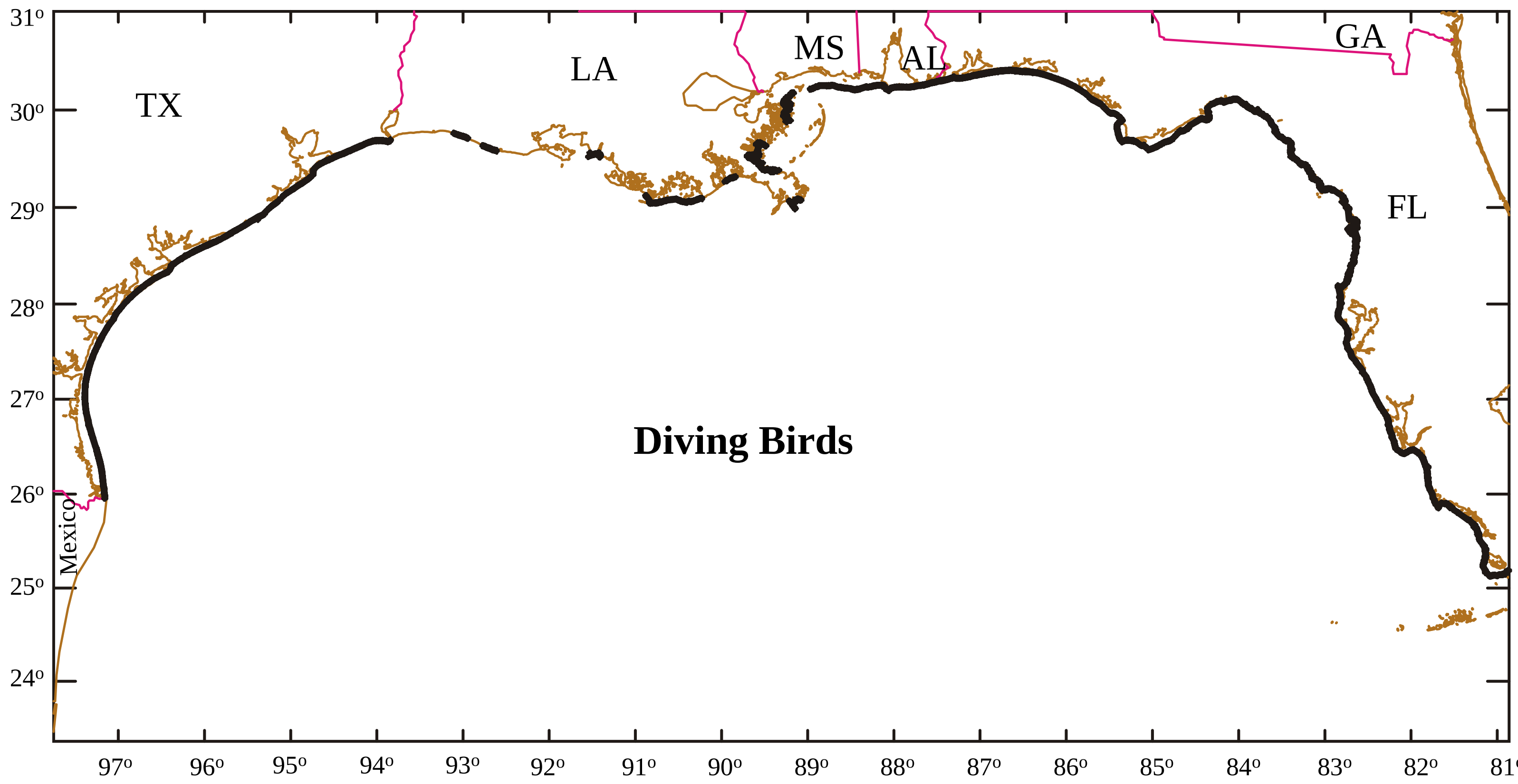

Figure 7. Locations of Diving Bird Habitat. (Shading is not to scale.)

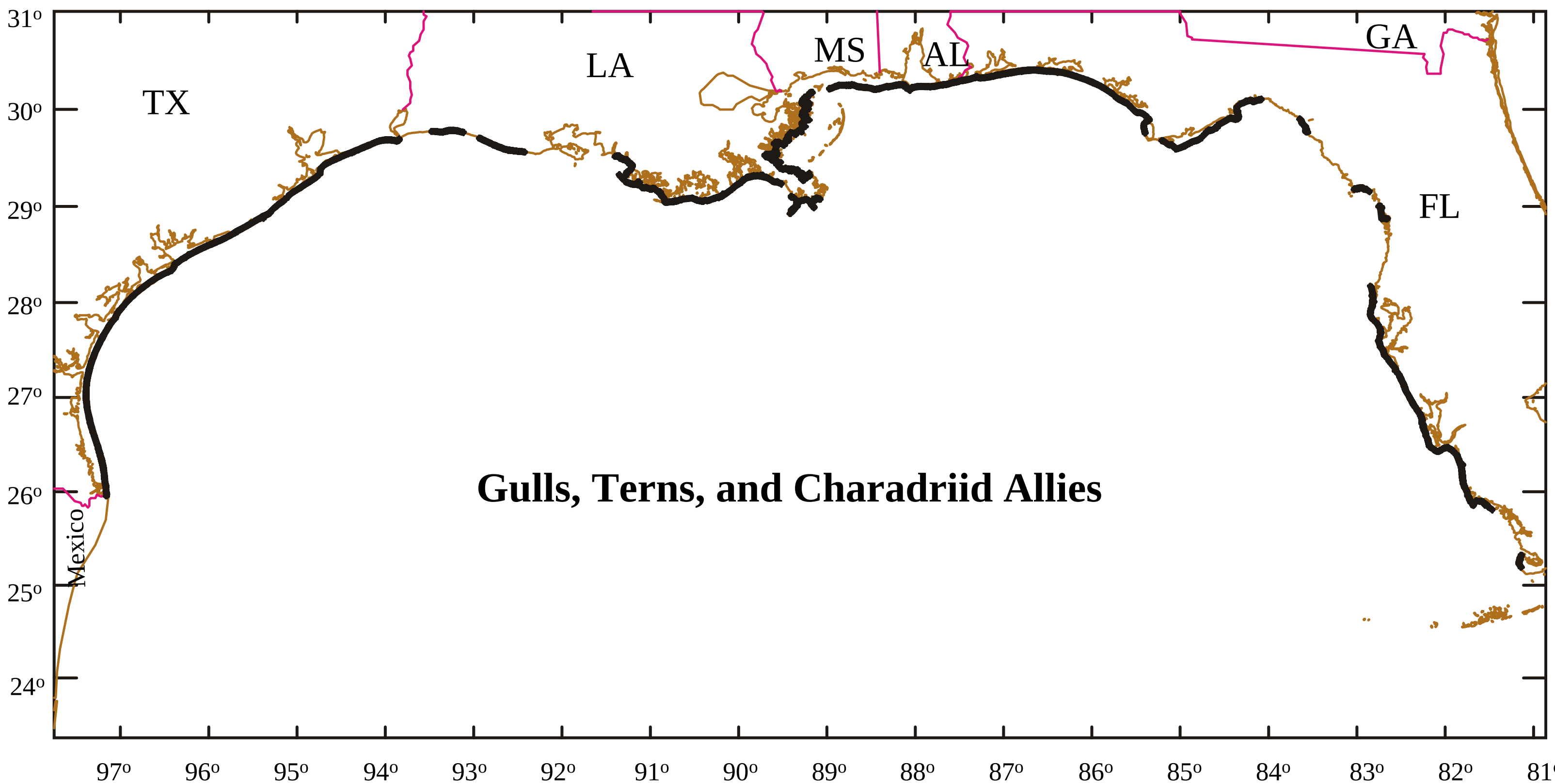

Figure 8. Locations of Gulls, Terns, and Charadriid Allies Habitat. (Shading is not to scale.)

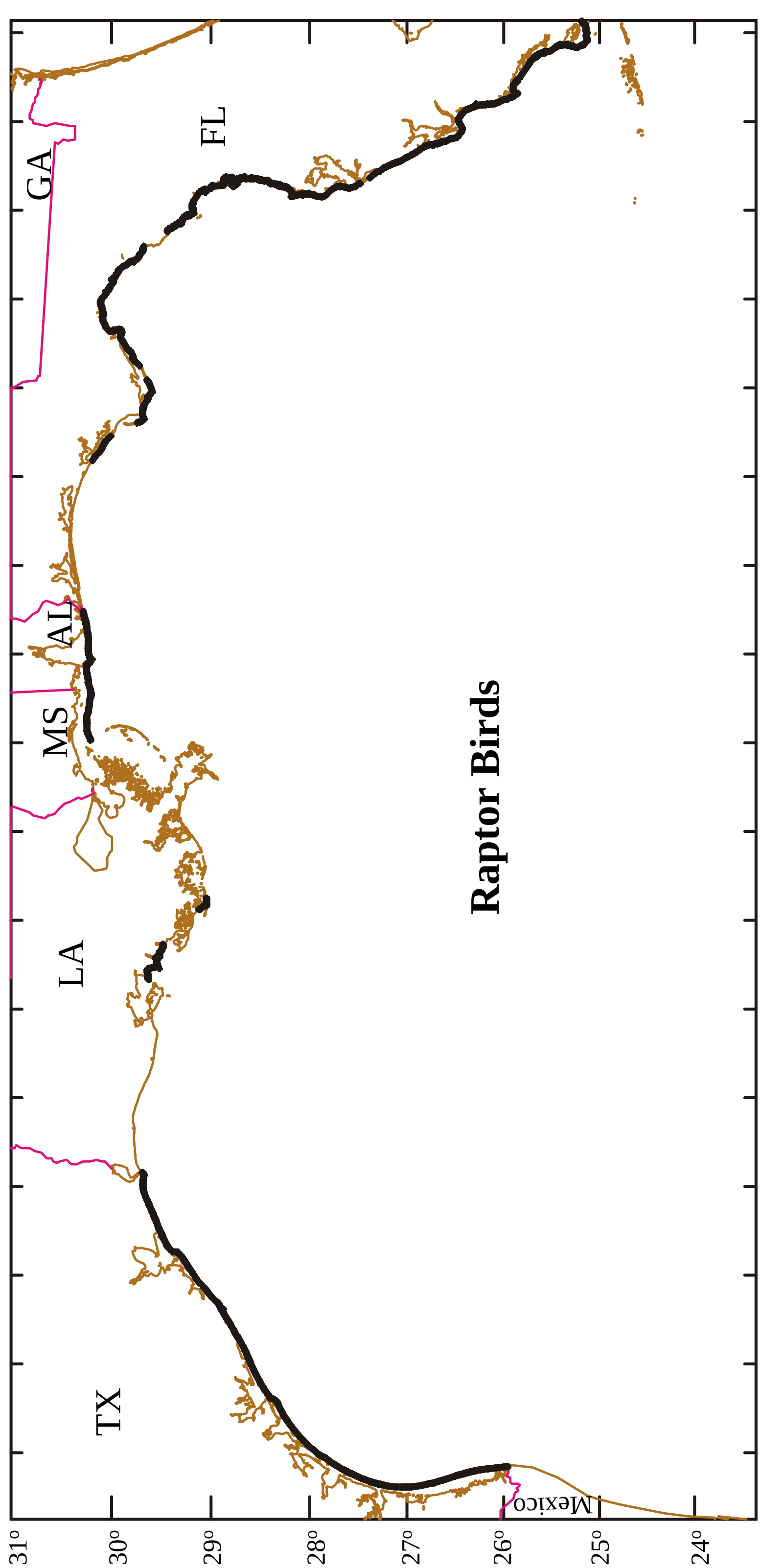

Figure 9. Locations of Raptor Bird Habitat. (Shading is not to scale.)

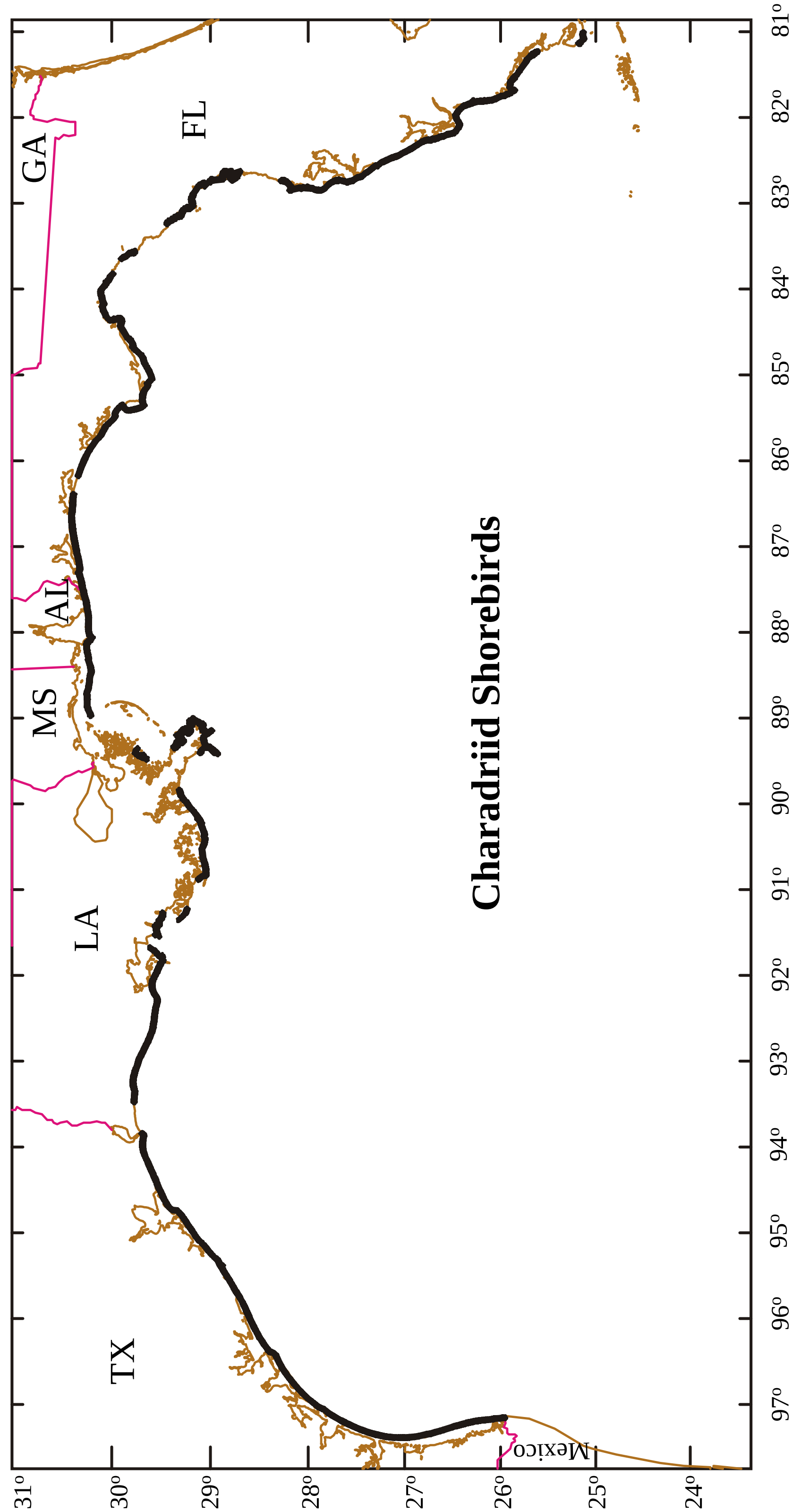

Figure 10. Locations of Charadriid Shorebird Habitat. (Shading is not to scale.)

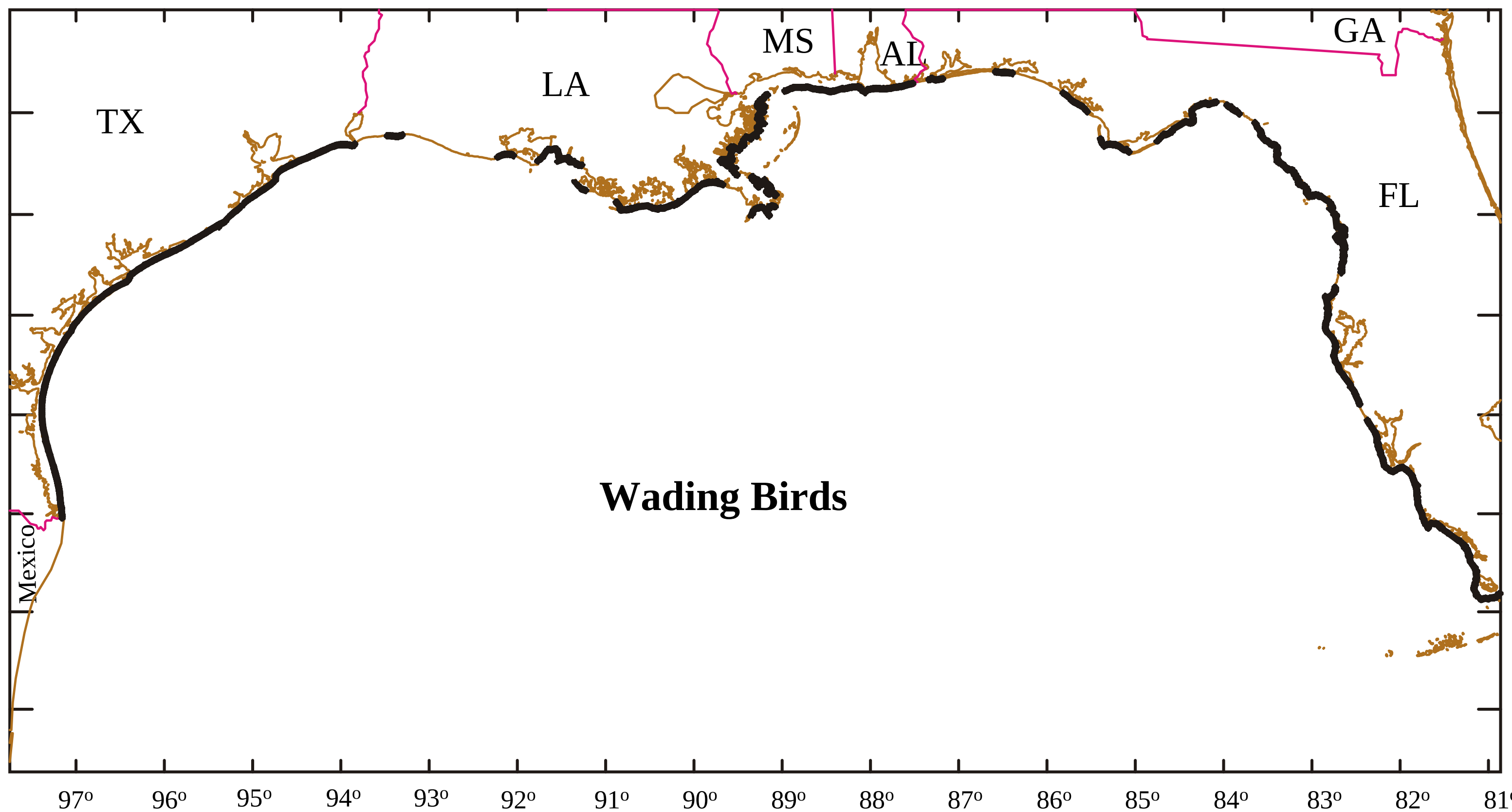

Figure 11. Locations of Wading Bird Habitat. (Shading is not to scale.)

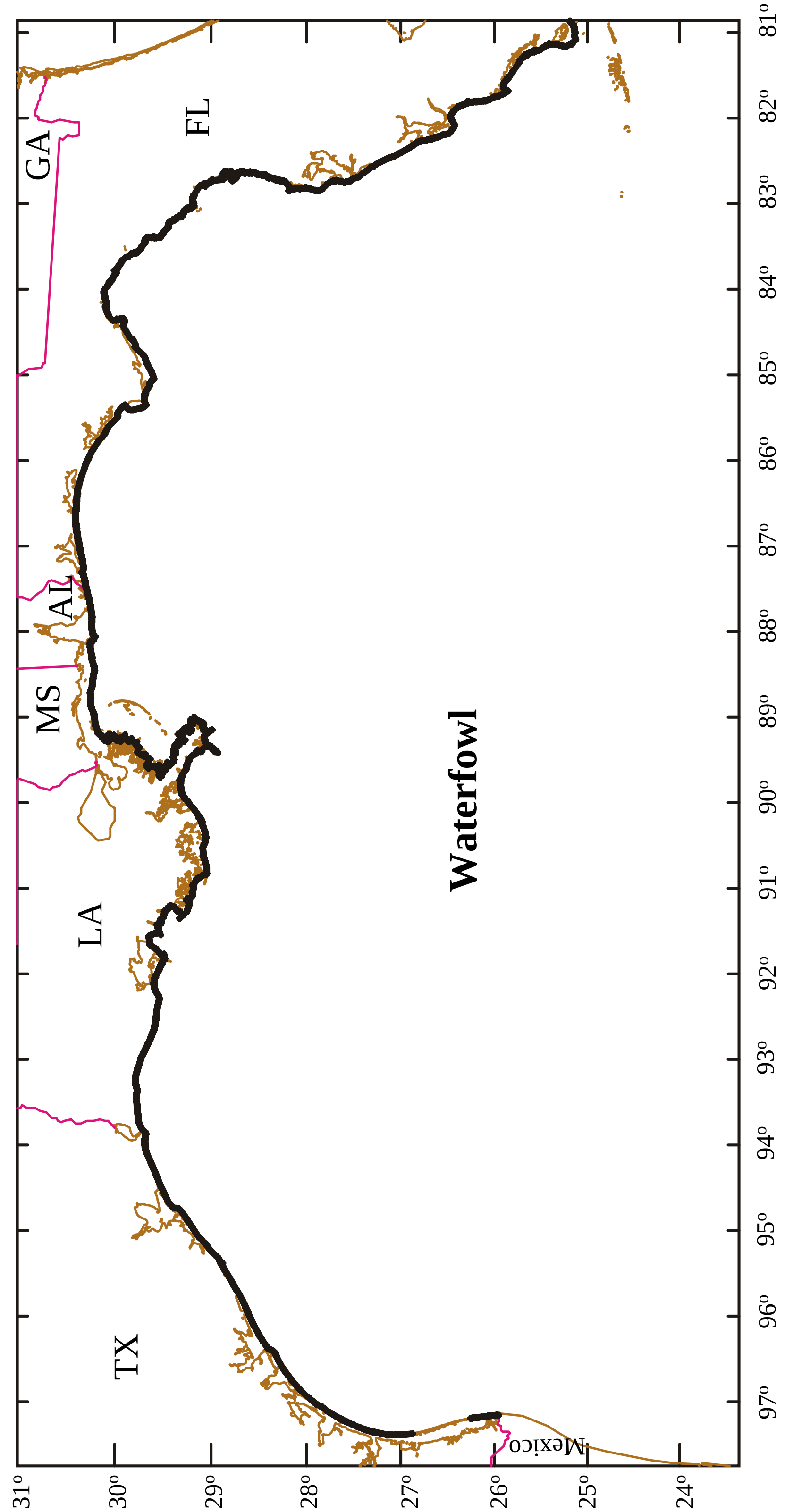

Figure 12. Locations of Waterfowl Habitat. (Shading is not to scale.)

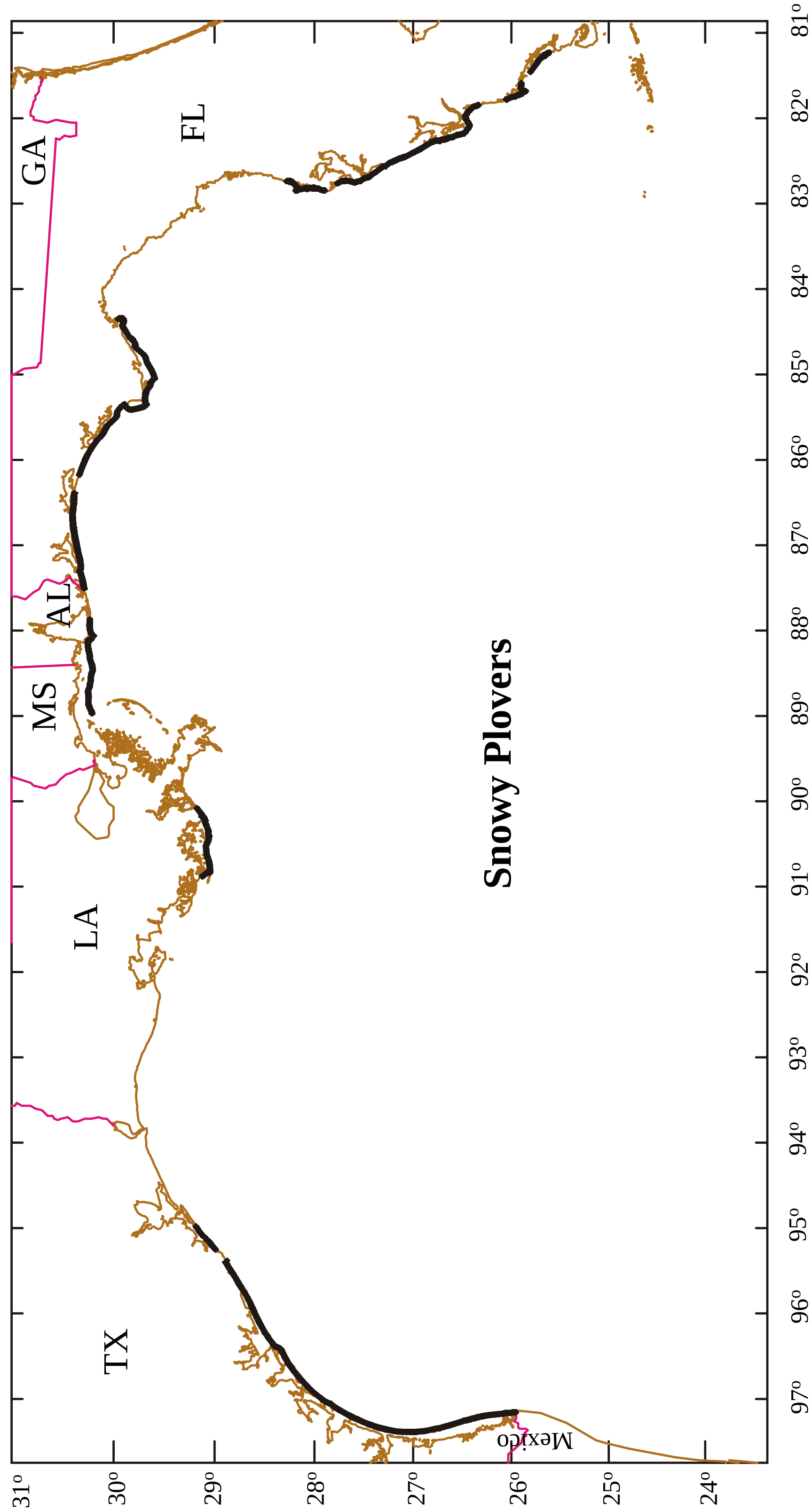

Figure 13. Locations of Snowy Plover Habitat (February-August). (Shading is not to scale.)

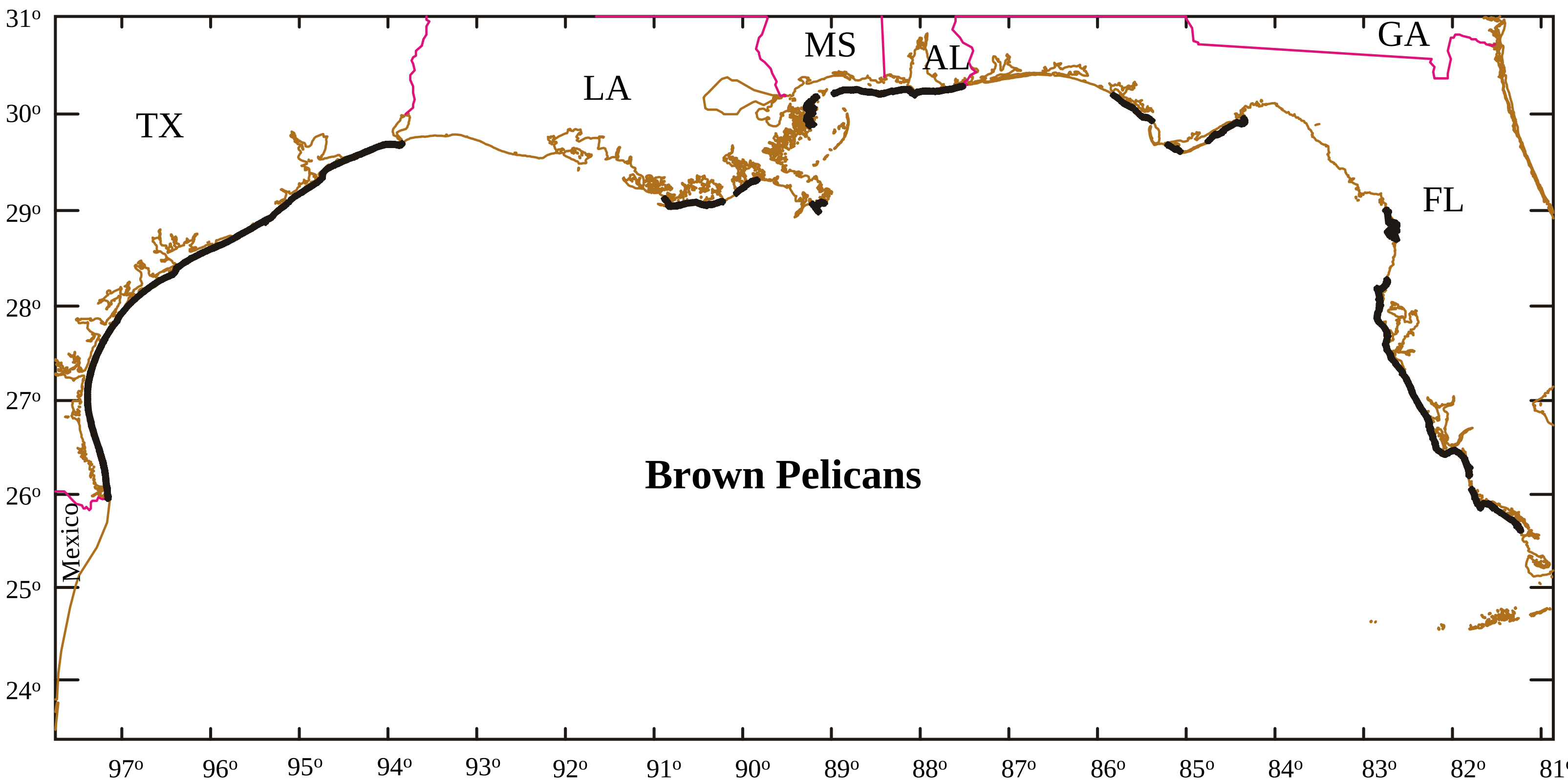

Figure 14. Locations of Brown Pelican Habitat. (Shading is not to scale.)

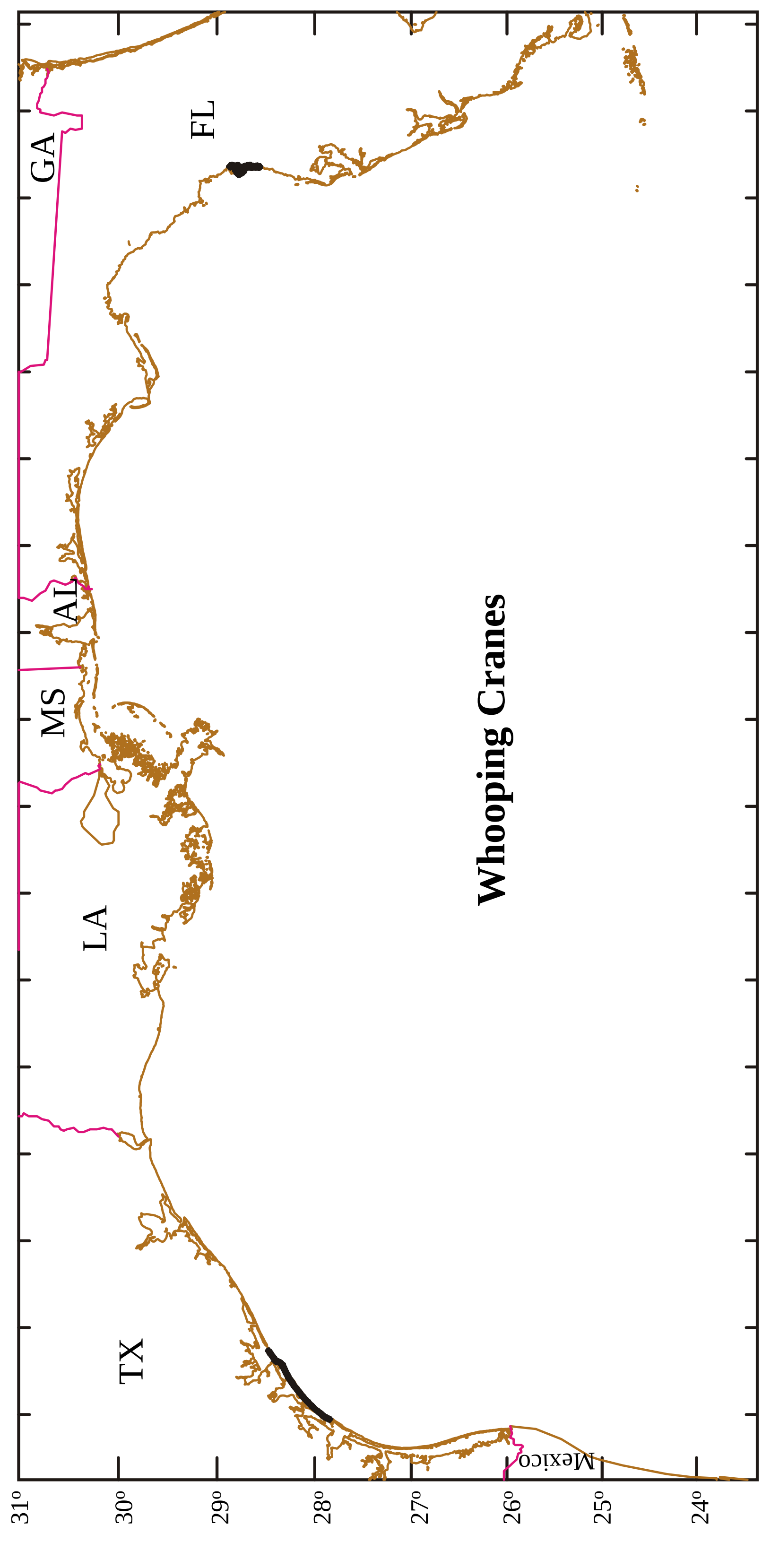

Figure 15. Locations of Whooping Crane Habitat (November-April). (Shading is not to scale.)

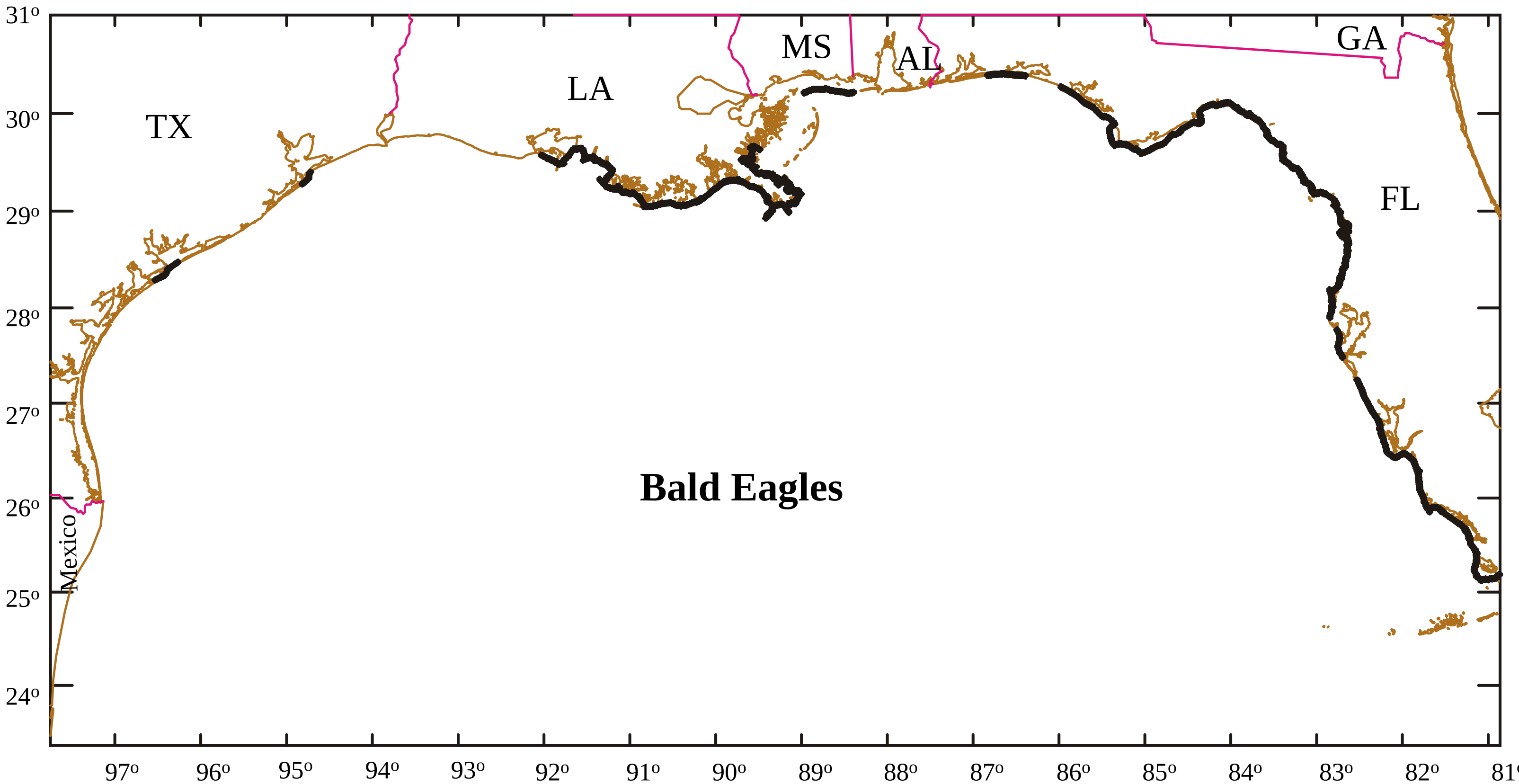

Figure 16. Locations of Bald Eagle Habitat. (Shading is not to scale.)

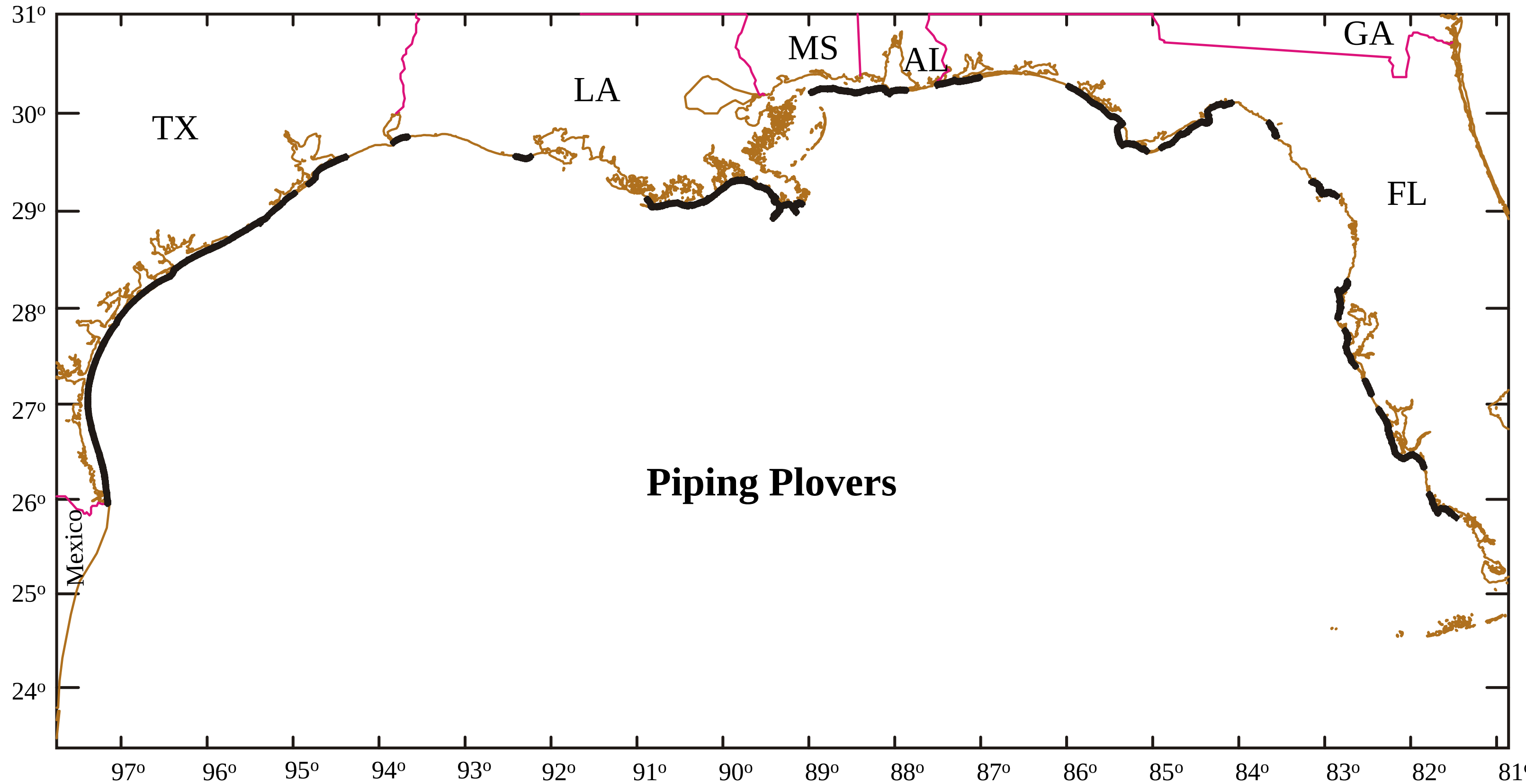

Figure 17. Locations of Piping Plover Habitat (July-May). (Shading is not to scale.)

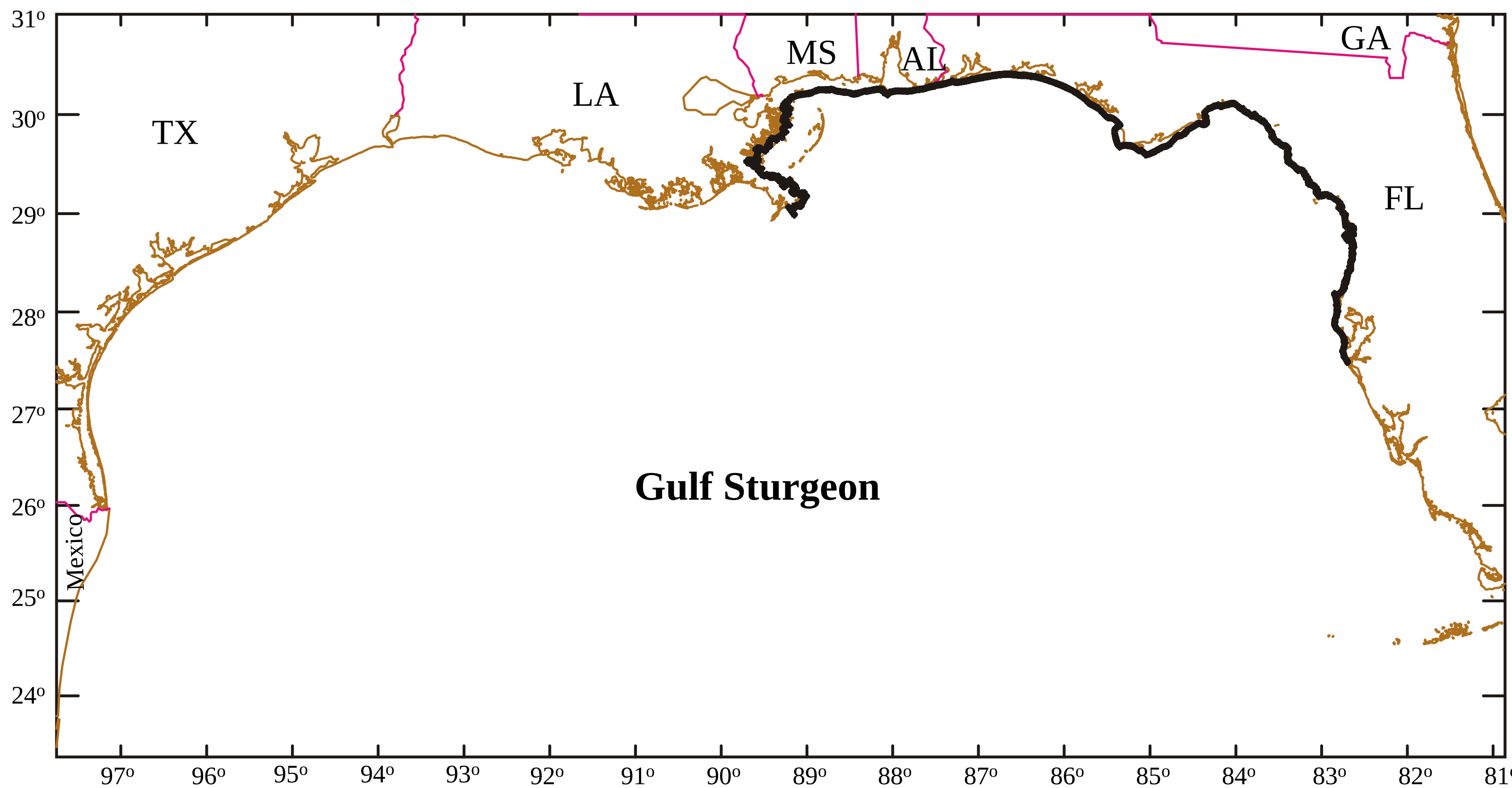

Figure 18. Known Shoreline Locations of Gulf Sturgeon Habitat. (Shading is not to scale.)

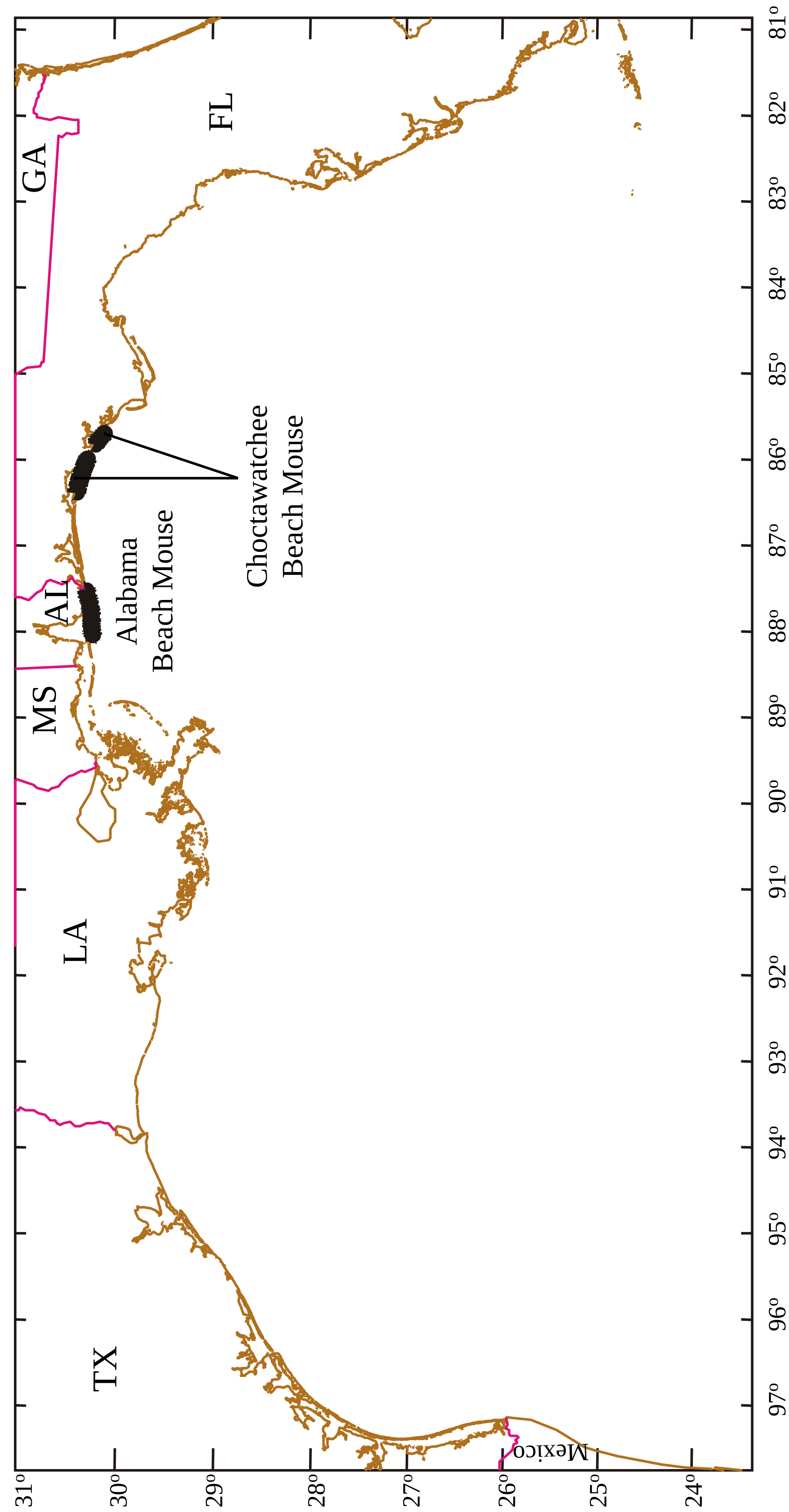

Figure 19. Locations of Alabama Beach Mouse and Choctawatchee Beach Mouse Habitat. (Shading is not to scale.)

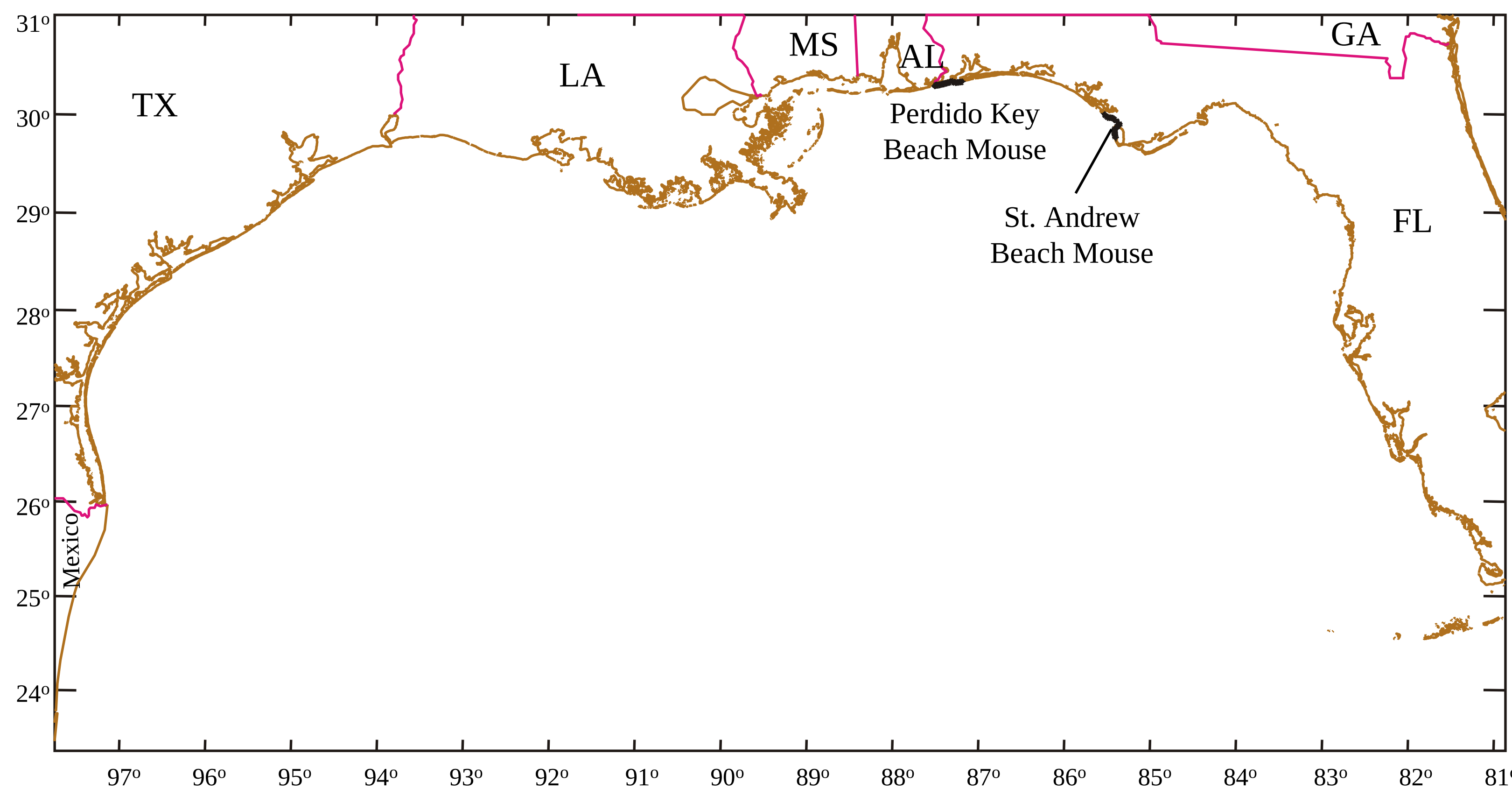

Figure 20. Locations of Perdido Key Beach Mouse and St. Andrew Beach Mouse Habitat. (Shading is not to scale.)

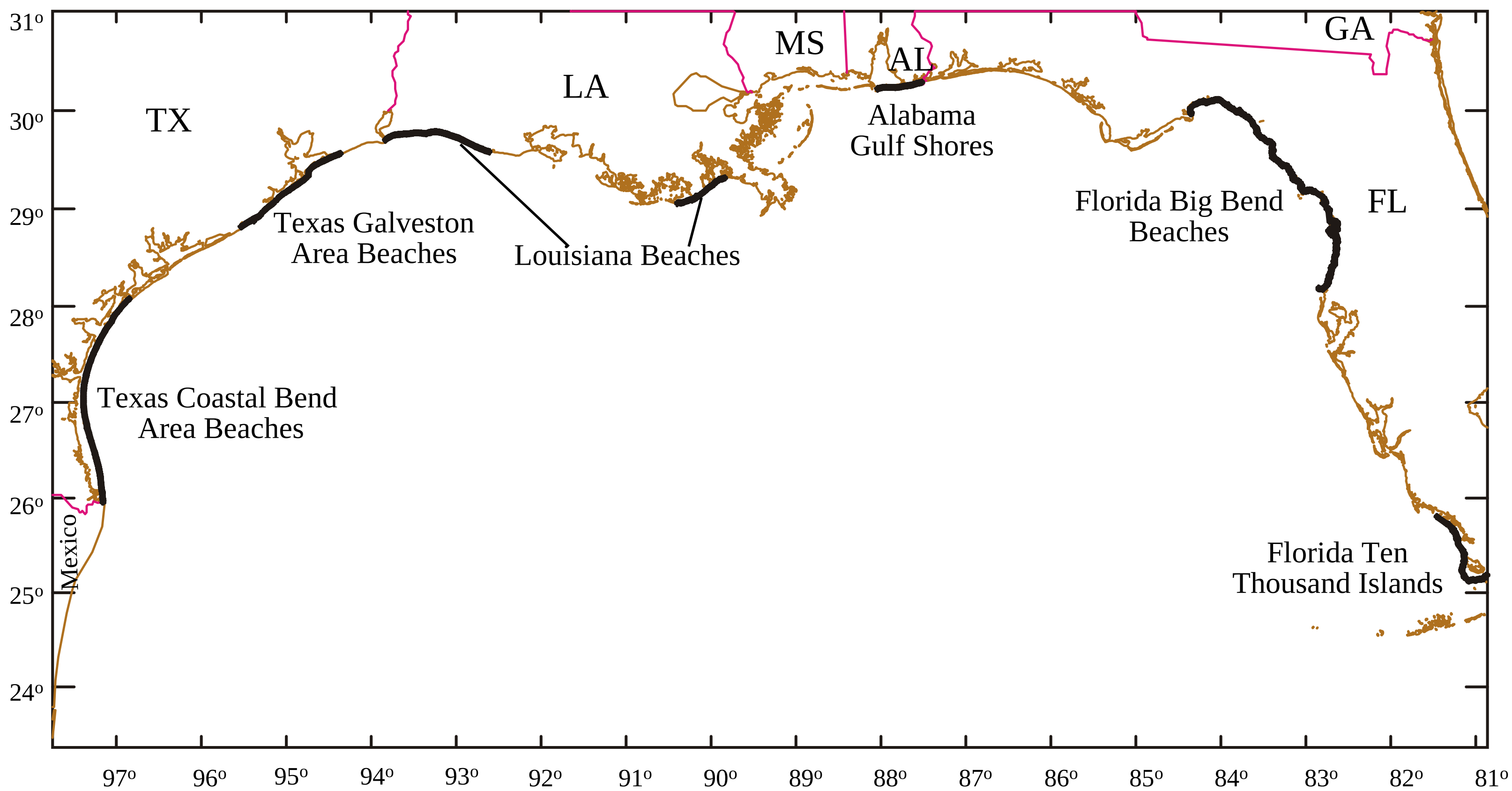

Figure 21. Locations of Texas Coastal Bend Area Beaches, Texas Galveston Area Beaches, Louisiana Beaches, Alabama Gulf Shores, Florida Big Bend Beaches, and Florida Ten Thousand Islands. (Shading is not to scale.) (Periods of use for Texas beaches is April-September, and periods of use for all other beaches is April-November).

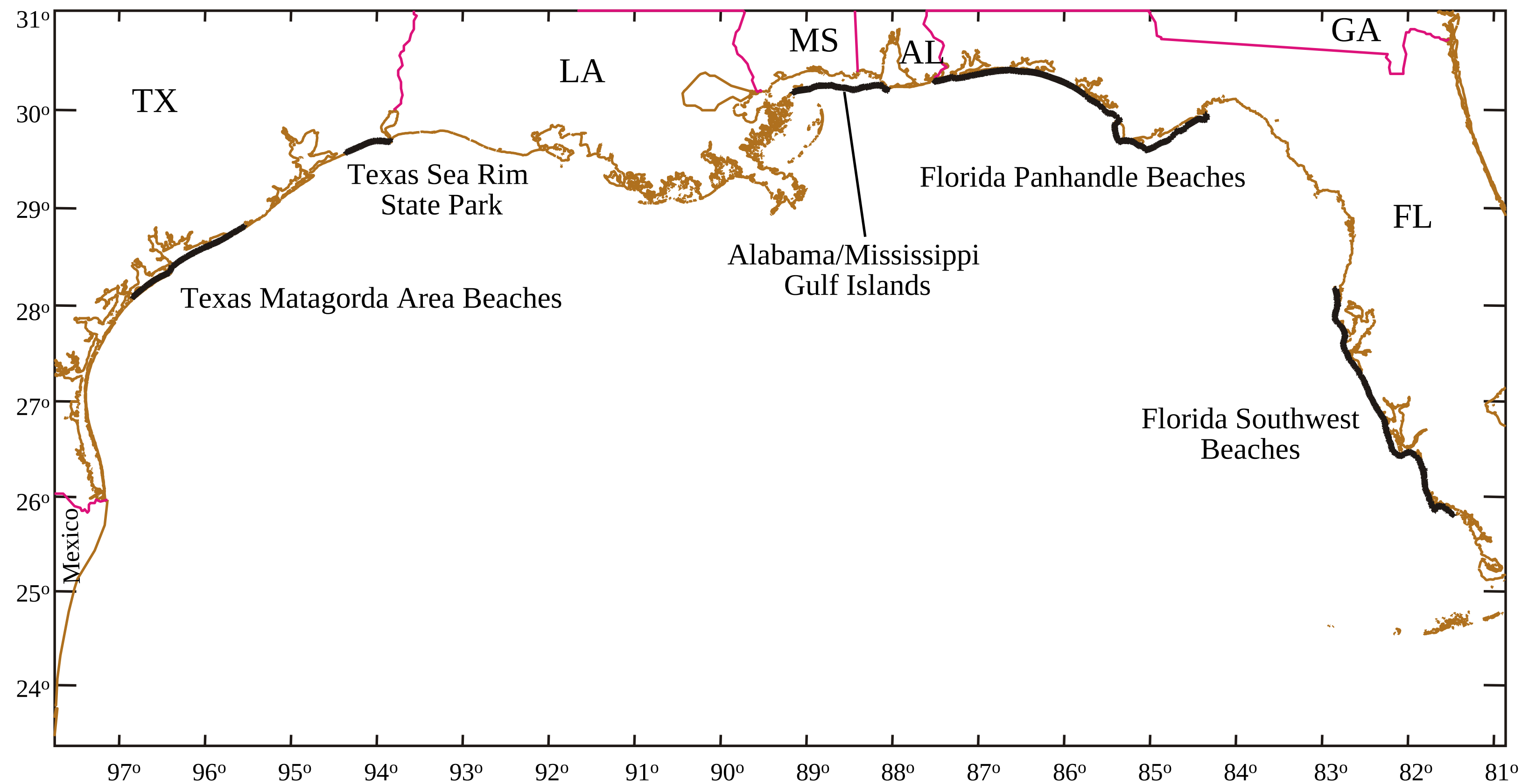

Figure 22. Locations of Texas Matagorda Area Beaches, Texas Sea Rim State Park, Alabama/Mississippi Gulf Islands, Florida Panhandle Beaches, and Florida Southwest Beaches. (Shading is not to scale.) (Periods of use for Texas beaches is April-September, and periods of use for all other beaches is April-November).

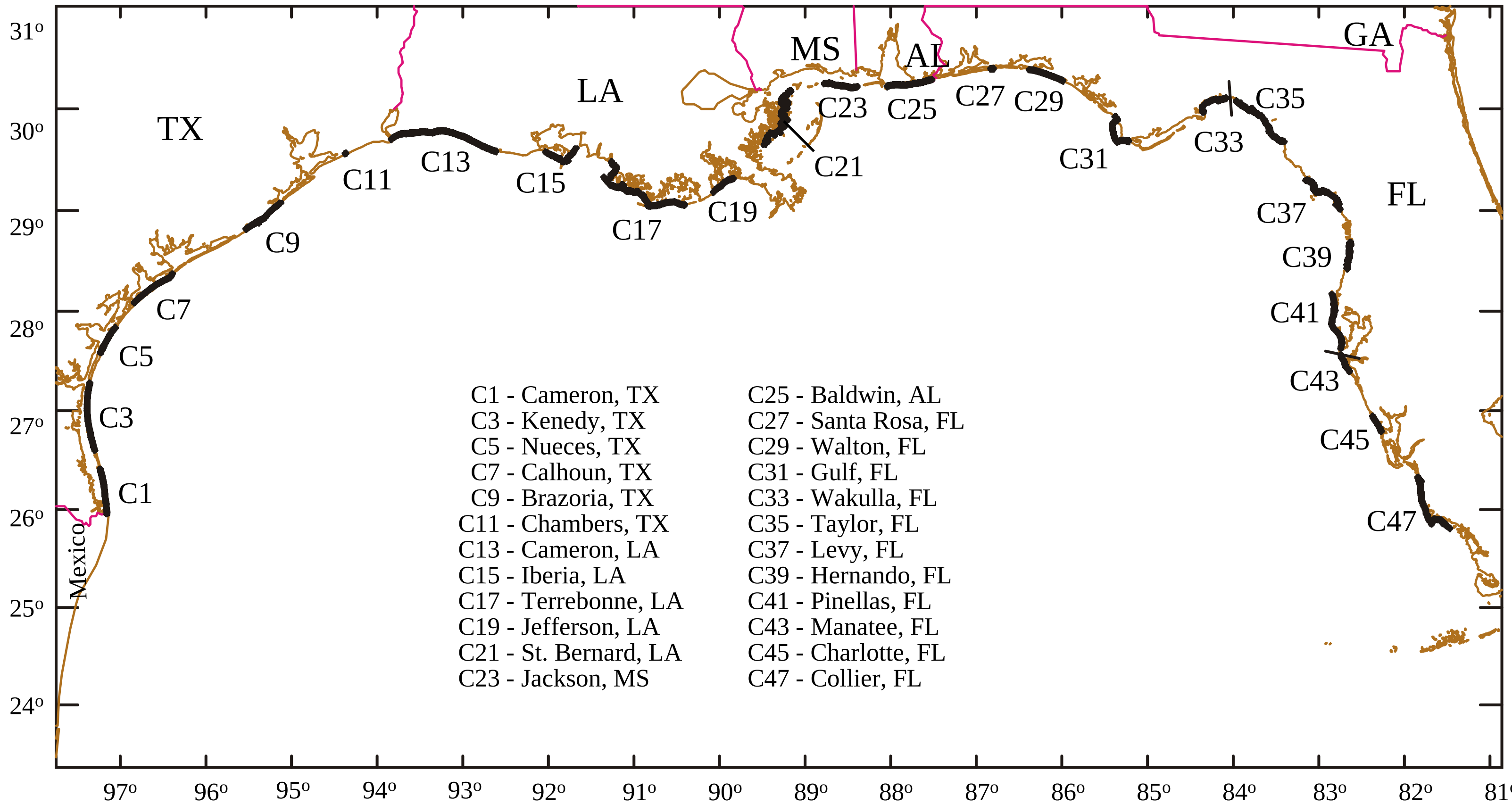

Figure 23. Locations of Gulf of Mexico Counties and Parishes (set 1). (Shading is not to scale.)

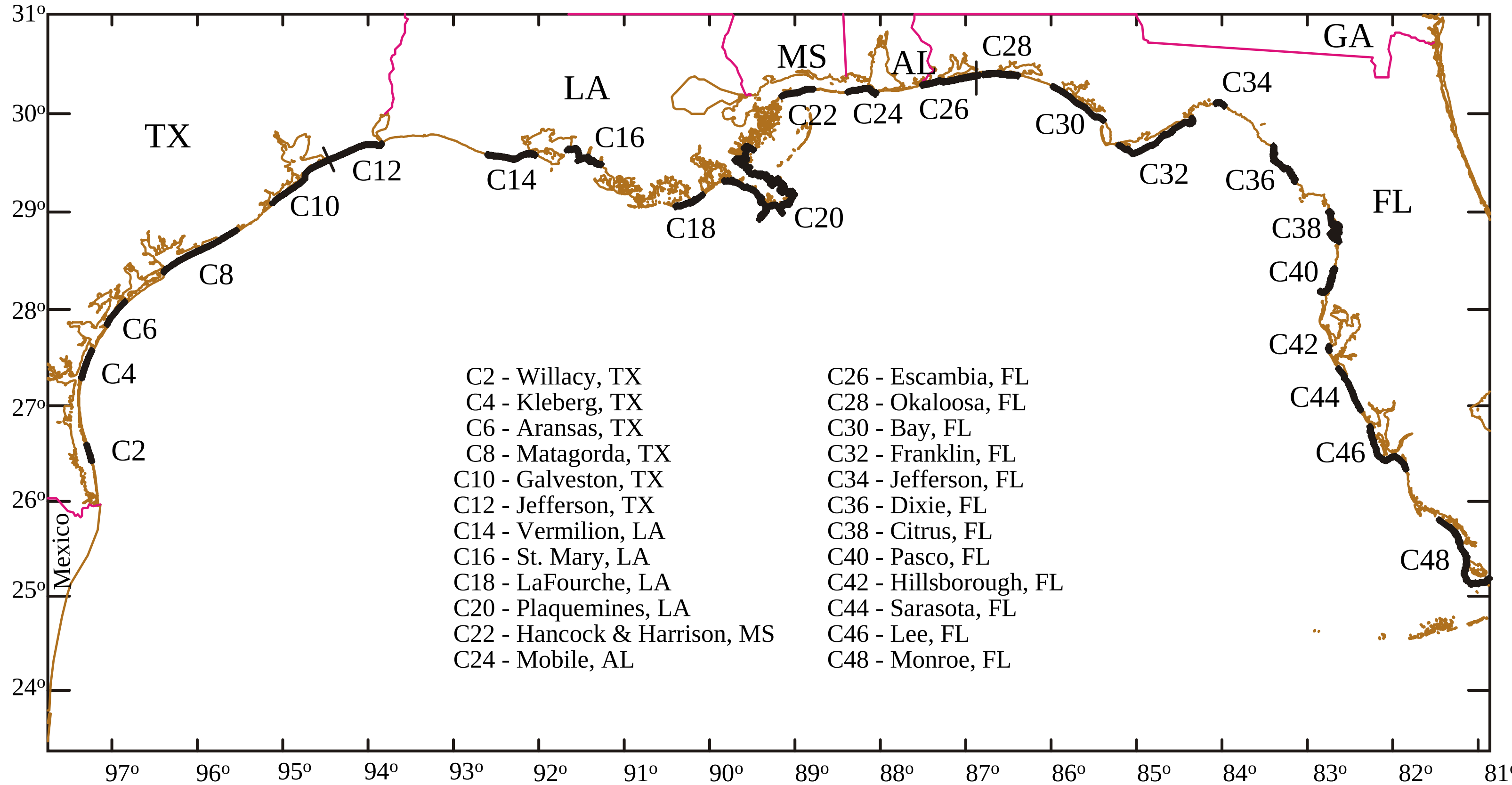

Figure 24. Locations of Gulf of Mexico Counties and Parishes (set 2). (Shading is not to scale.)

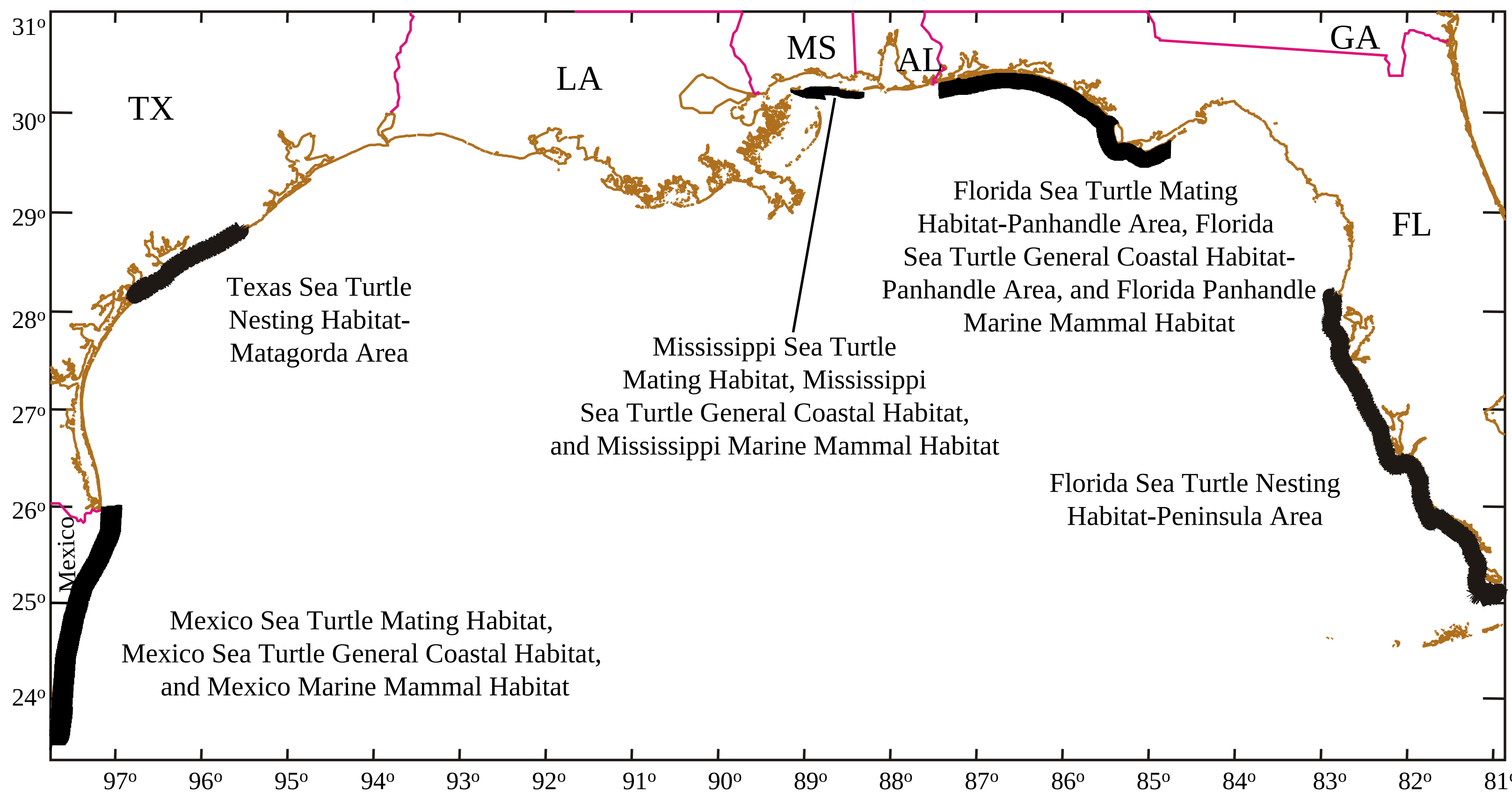

Figure 25. Locations of Mexico Sea Turtle Mating Habitat (March-July), Mexico Sea Turtle General Coastal Habitat (January-December), Mexico Marine Mammal Habitat (January-December), Texas Sea Turtle Nesting Habitat-Matagorda Area (April-September) Mississippi Sea Turtle Mating Habitat (March-July) Mississippi Sea Turtle General Coastal Habitat (January-December) Mississippi Marine Mammal Habitat (January-December) Florida Sea Turtle Mating Habitat-Panhandle Area (March-July), Florida Sea Turtle General Coastal Habitat-Panhandle Area (January-December), Florida Panhandle Marine Mammal Habitat (January-December), and Florida Sea Turtle Nesting Habitat-Peninsula Area (April-November). (Shading is not to scale.)

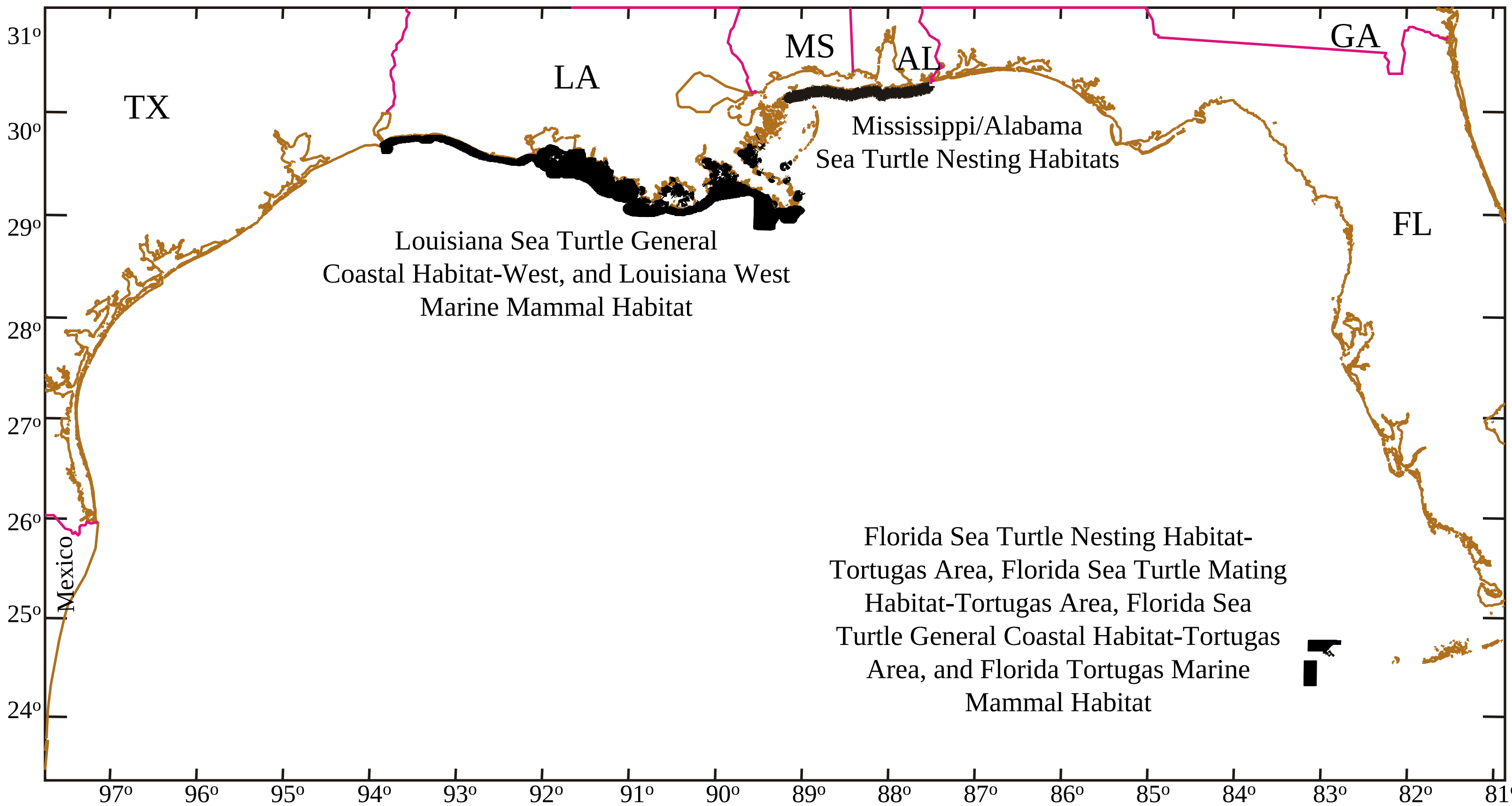

Figure 26. Locations of Louisiana Sea Turtle General Coastal Habitat-West (January-December), Louisiana West Marine Mammal Habitat (January-December), Mississippi/Alabama Sea Turtle Nesting Habitats (April-November), Florida Sea Turtle Nesting Habitat-Tortugas Area (April-November), Florida Sea Turtle Mating Habitat-Tortugas Area (March-July), Florida Sea Turtle General Coastal Habitat-Tortugas Area (January-December), and Florida Tortugas Marine Mammal Habitat (January-December). (Shading is not to scale.)

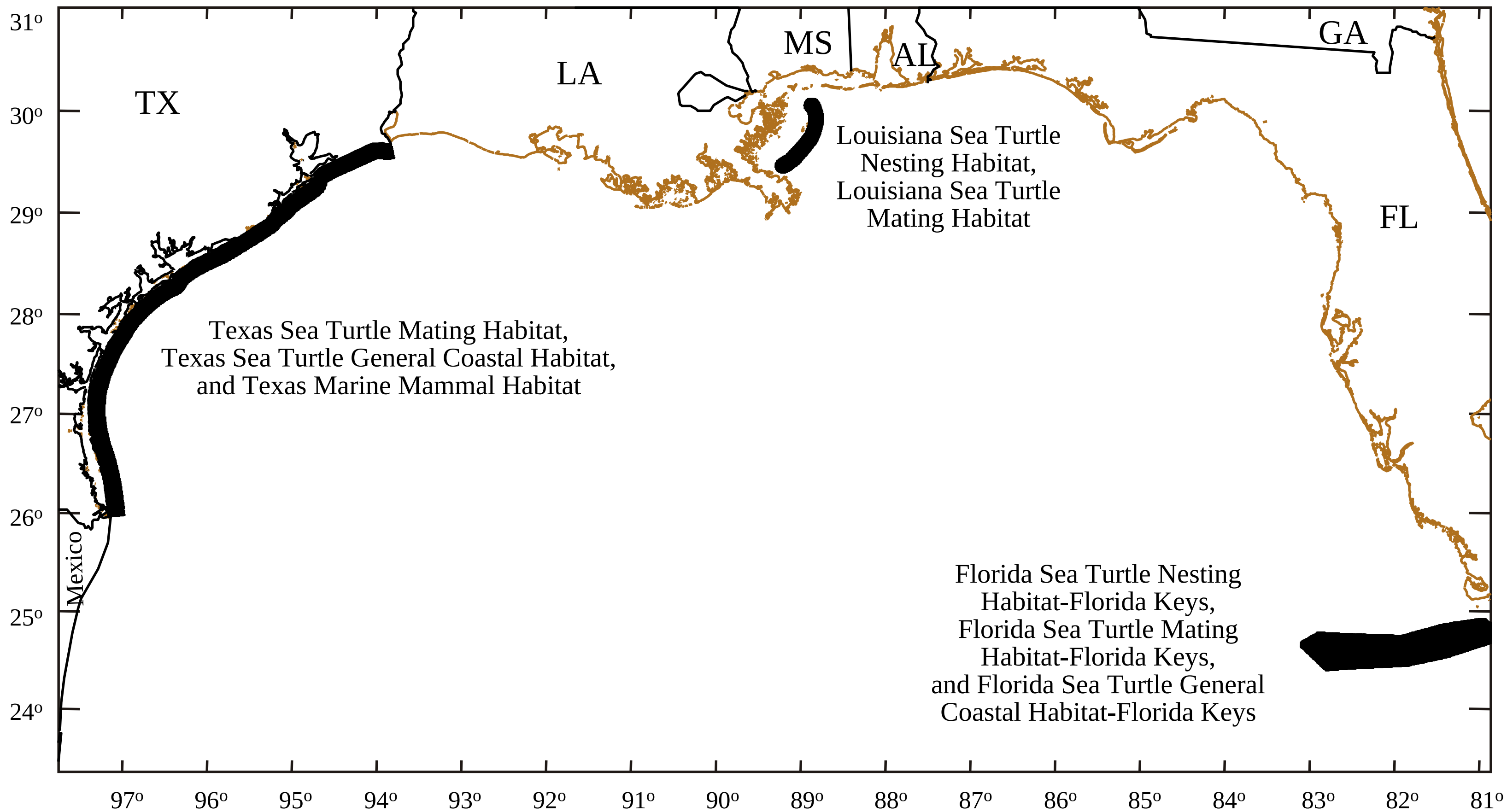

Figure 27. Locations of Texas Sea Turtle Mating Habitat (March-July), Texas Sea Turtle General Coastal Habitat (January-December), Texas Marine Mammal Habitat (January-December), Louisiana Sea Turtle Nesting Habitat (April-November) Louisiana Sea Turtle Mating Habitat (March-July), Florida Sea Turtle Nesting Habitat-Florida Keys (April-November), Florida Sea Turtle Mating Habitat-Florida Keys (March-July), and Florida Sea Turtle General Coastal Habitat-Florida Keys (January-December). (Shading is not to scale.)

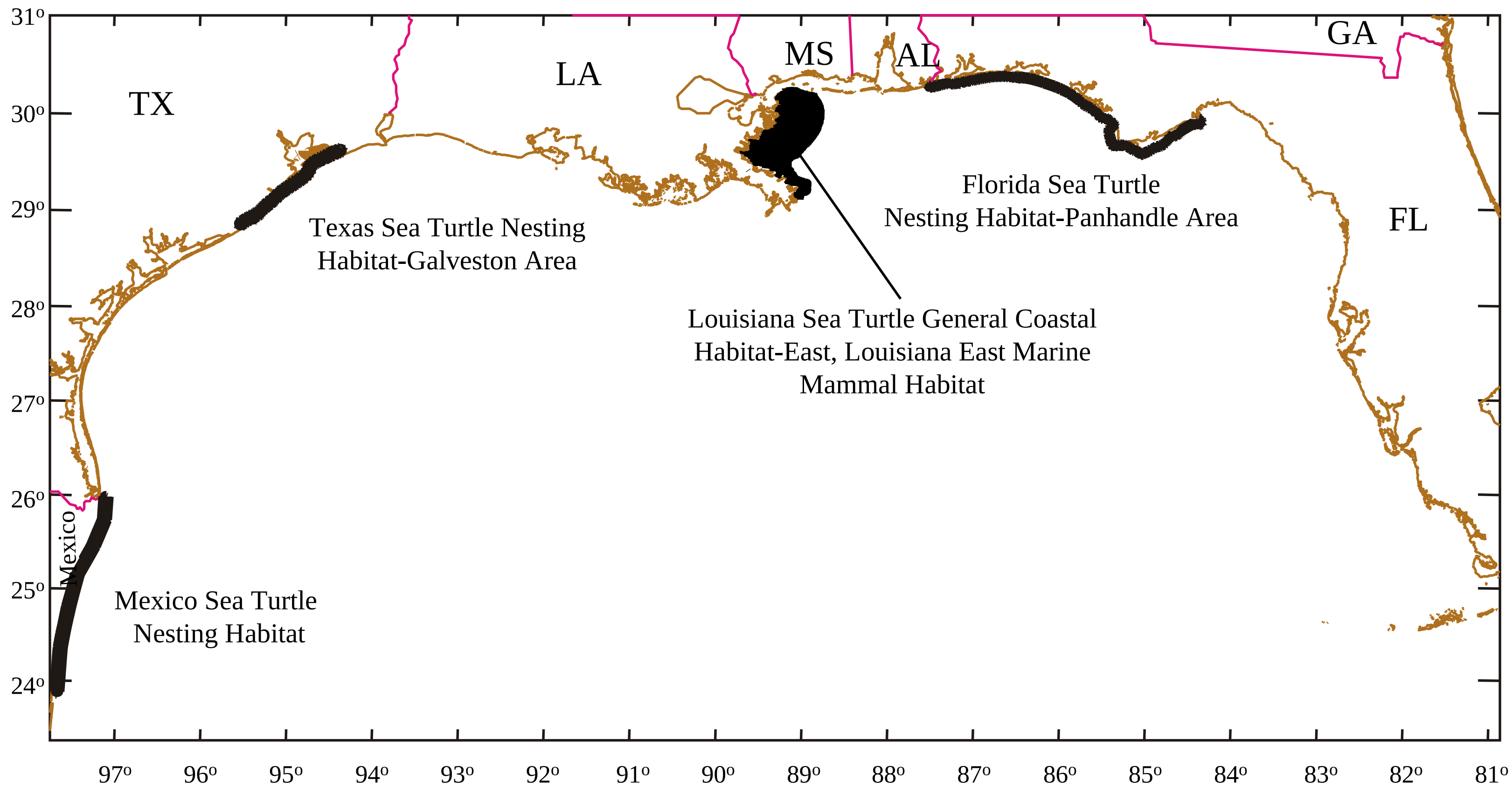

Figure 28. Locations of Mexico Sea Turtle Nesting Habitat (April-September), Texas Sea Turtle Nesting Habitat-Galveston Area (April-September), Louisiana Sea Turtle General Coastal Habitat-East (January-December), Louisiana East Marine Mammal Habitat (January-December), and Florida Sea Turtle Nesting Habitat-Panhandle Area (April-November). (Shading is not to scale.)

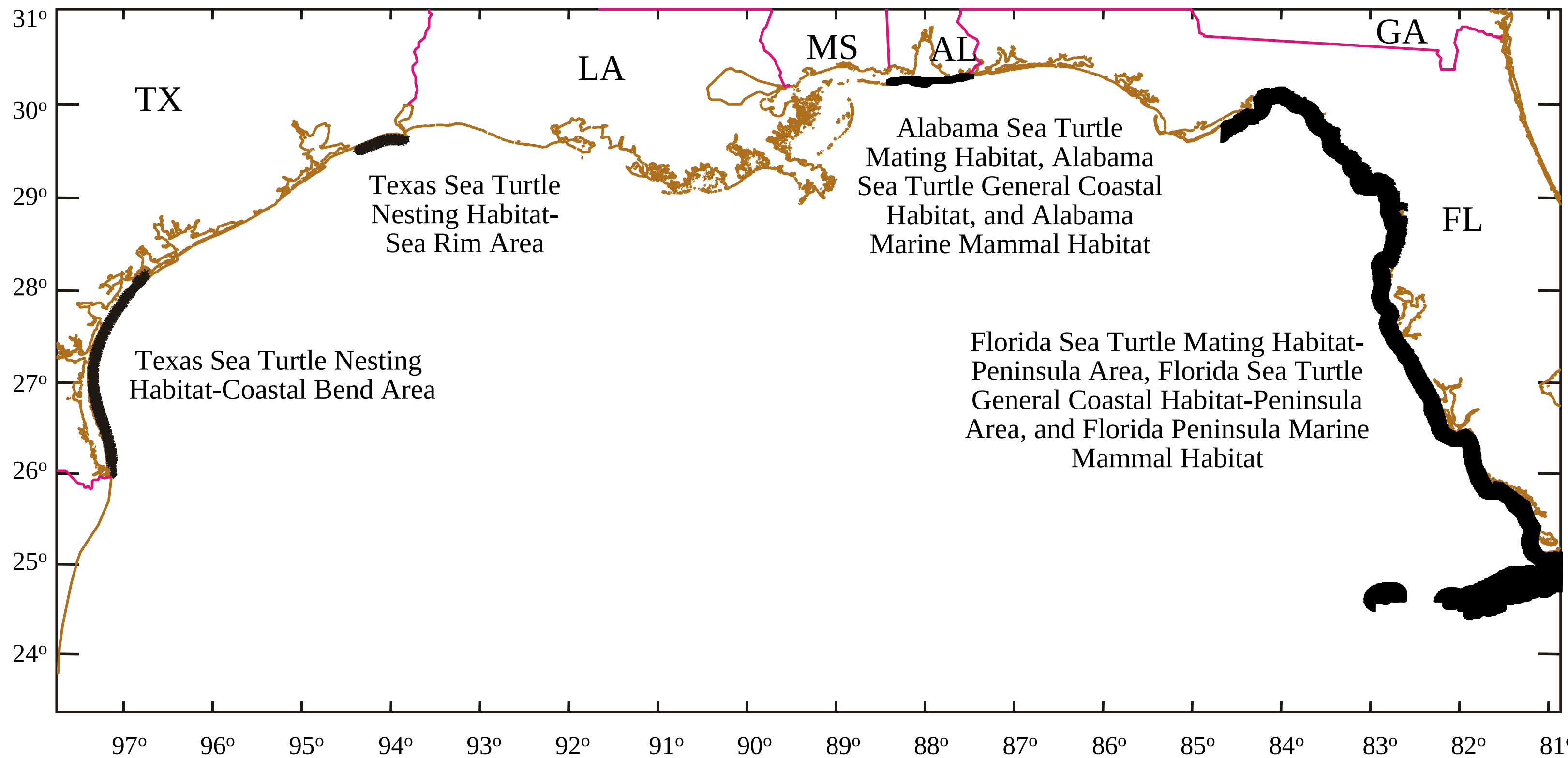

Figure 29. Locations of Texas Sea Turtle Nesting Habitat-Coastal Bend Area (April-September), Texas Sea Turtle Nesting Habitat-Sea Rim Area (April-September), Alabama Sea Turtle Mating Habitat (March-July), Alabama Sea Turtle General Coastal Habitat (January-December), Alabama Marine Mammal Habitat (January-December), Florida Sea Turtle Mating Habitat-Peninsula Area (March-July), Florida Sea Turtle General Coastal Habitat-Peninsula Area, and Florida Peninsula Marine Mammal Habitat (January-December). (Note: Shading is not to scale.)

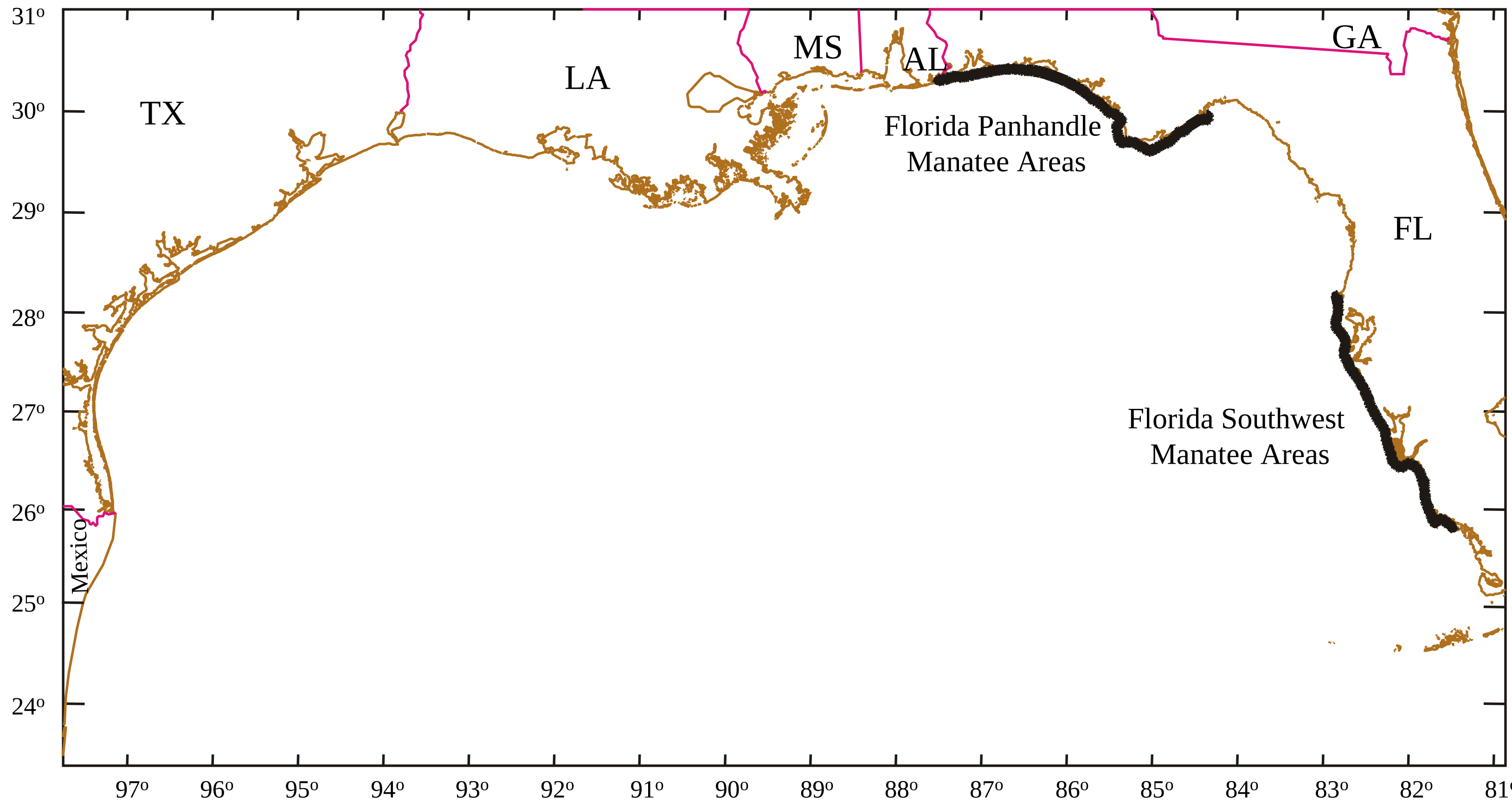

Figure 30. Locations of Florida Panhandle Manatee Areas (December-March and April-November) and Florida Southwest Manatee Areas (December-March and April-November). (Shading is not to scale.)

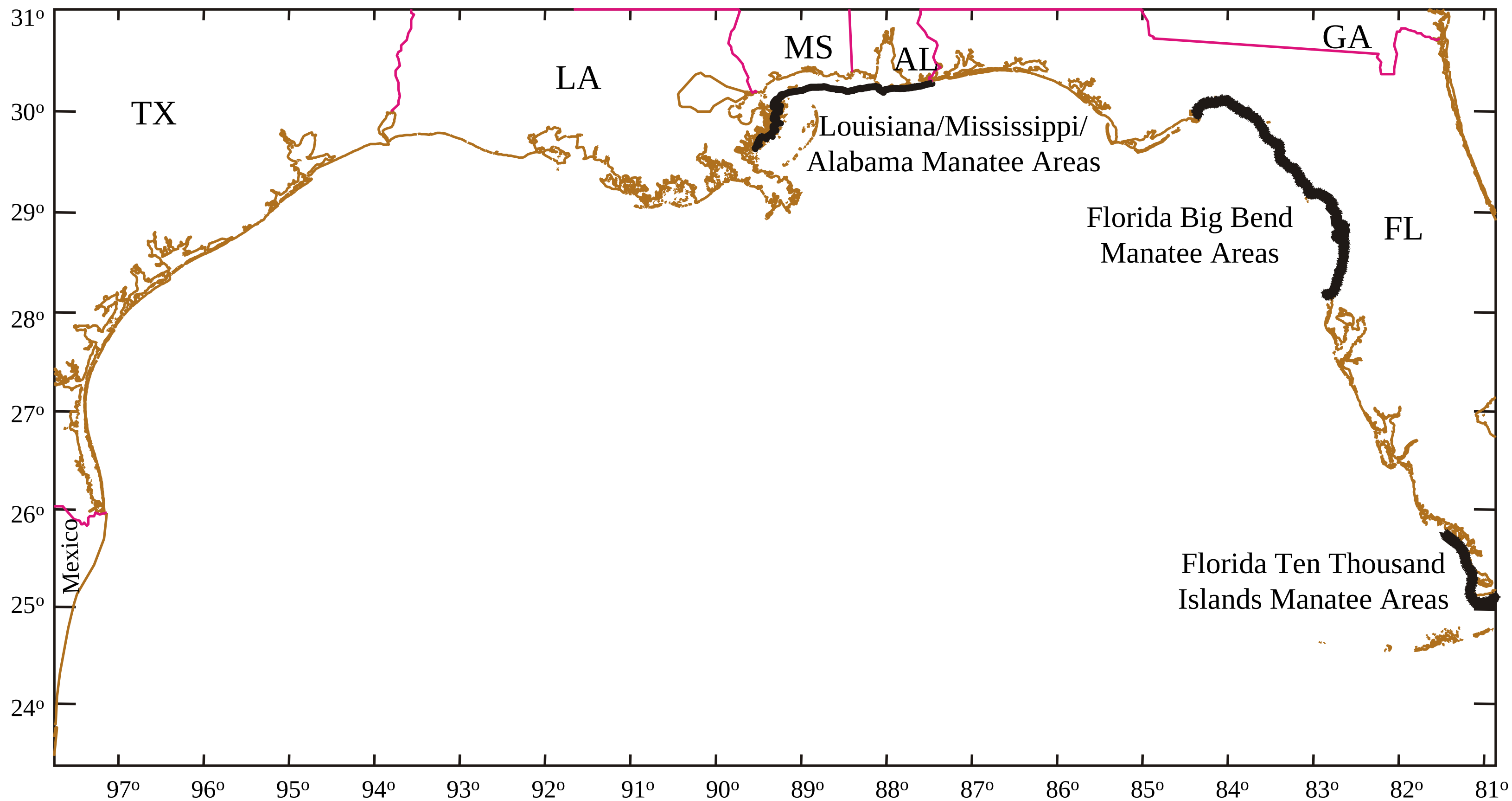

Figure 31. Locations of Louisiana/Mississippi/Alabama Manatee Areas (April-November), Florida Big Bend Manatee Areas (December-March and April-November), and Florida Ten Thousand Islands Manatee Areas (December-March and April-November). (Shading is not to scale.)

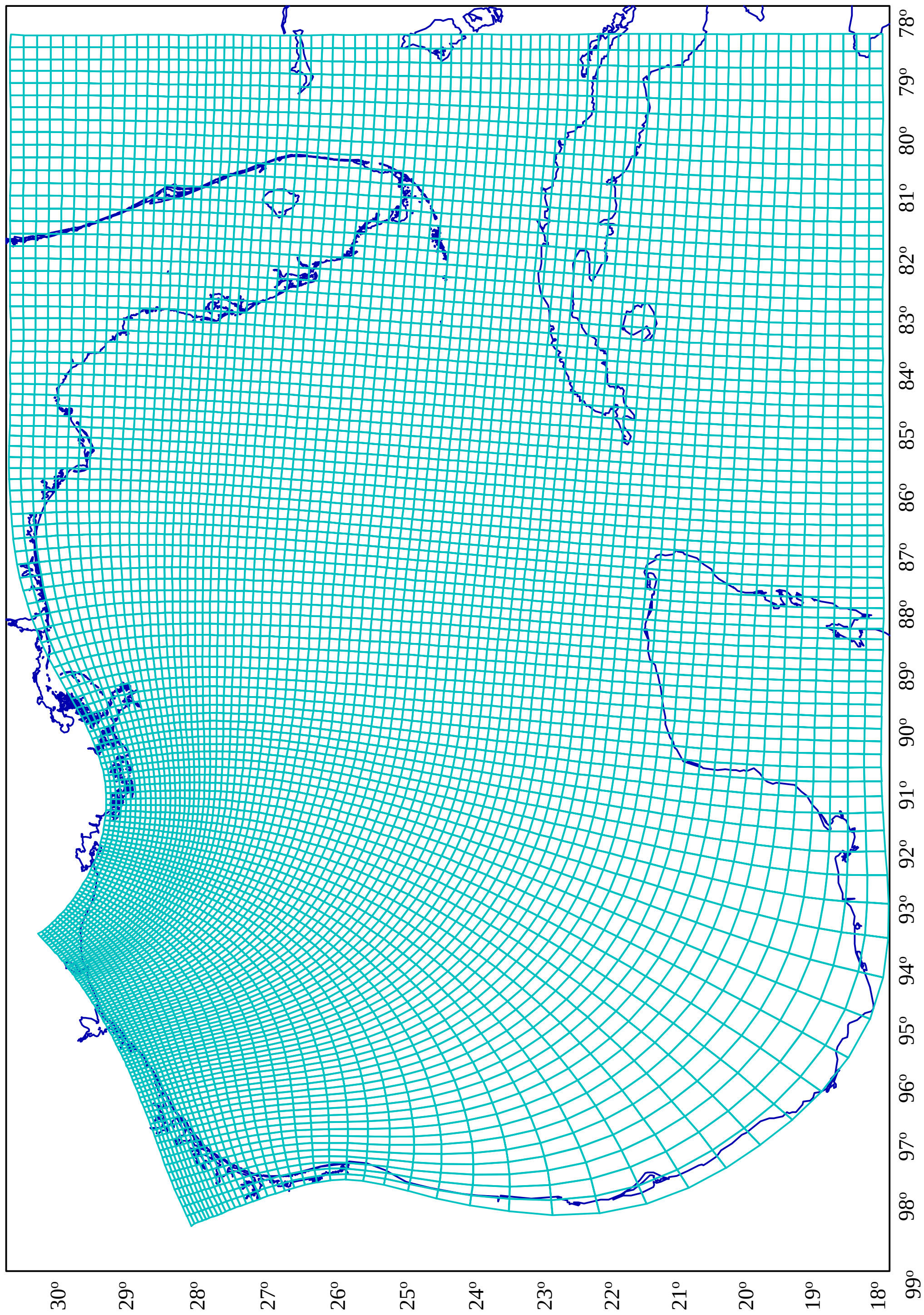

Figure 32. Computational Grid Used by Dynalysis of Princeton in the Mellor-Blumberg Primitive Equation Model Adapted to the Gulf of Mexico

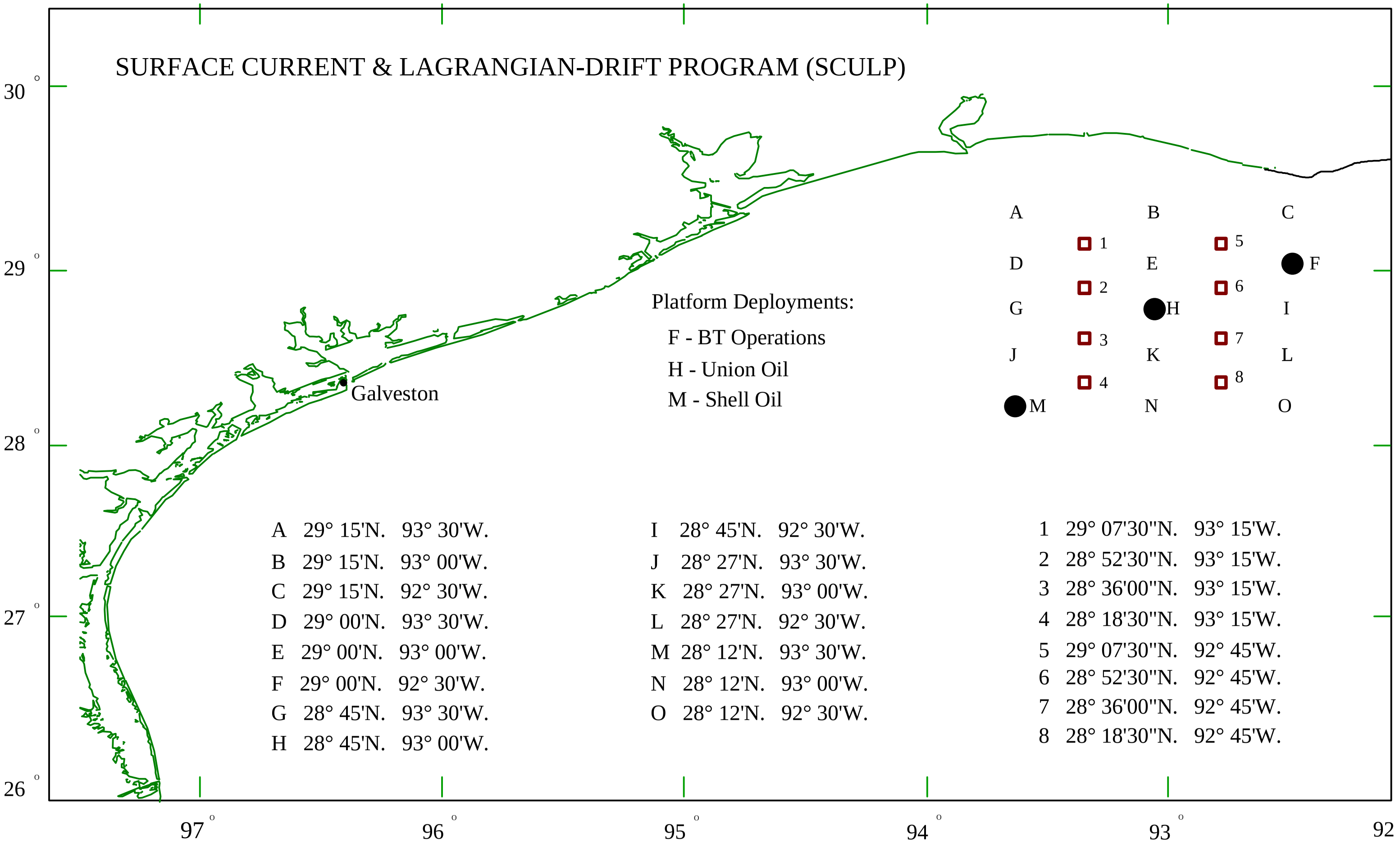

Figure 33. Deployment Locations of the SCULP Drifters. The letters designate the initial aircraft-deployment locations except for F, H, and M, which were offshore production platforms (filled dots). Buoys were deployed weekly from the platforms and monthly from other lettered stations. Additional aircraft deployments were made from the numbered locations (open boxes).

Table 1a. Oil-spill occurrence probability estimates for offshore spills greater than or equal to **1,000 barrels** resulting from the proposed actions in the Western and Central Gulf of Mexico Planning Areas (2003-2007) and the Gulfwide Program (2003-2042)

	Volume (Bbbl)	Mean Number of spills from platforms	Mean Number of spills from pipelines	Mean Number of spills from tankers	Mean Number of spills (total)	Probability (% chance) of one or more spills from platforms	Probability (% chance) of one or more spills from pipelines	Probability (% chance) of one or more spills from tankers	Probability (% chance) of one or more spills (total)
Proposed Actions									
Western (Low Estimate)	0.136	0.02	0.19	0.00	0.21	2	17	n	19
Central (Low Estimate)	0.276	0.04	0.38	0.00	0.42	4	32	n	34
Western (High Estimate)	0.262	0.03	0.36	0.00	0.40	3	30	n	33
Central (High Estimate)	0.654	0.09	0.90	0.00	0.99	8	59	n	63
OCS Program									
Western (Low Estimate)	3.35	0.44	4.62	0.00	5.06	35	99	n	99
Central (Low Estimate)	12.00	1.56	16.57	0.00	18.13	79	**	n	**
Eastern (Low Estimate)	0.14	0.02	0.19	0.00	0.21	2	17	n	19
Gulfwide (Low Estimate)	15.49	2.00	21.21	0.00	23.21	86	**	n	**
Western (High Estimate)	5.53	0.72	7.20	0.23	8.15	51	**	20	**
Central (High Estimate)	16.52	2.15	21.50	0.68	24.33	88	**	49	**
Eastern (High Estimate)	0.37	0.05	0.51	0.00	0.56	5	40	n	43
Gulfwide (High Estimate)	22.42	2.93	29.38	0.93	33.24	95	**	60	**

Note: Bbbl = billion barrels; n = less than 0.5%; ** = greater than 99.5%.
"Platforms" refers to facilities used in exploration, development, or production.

Table 1b. Oil-spill occurrence probability estimates for offshore spills greater than or equal to **10,000 barrels** resulting from the proposed actions in the Western and Central Gulf of Mexico Planning Areas (2003-2007) and the Gulfwide Program (2003-2042)

	Volume	Mean Number of spills from			Mean Number of spills	Probability (% chance) of one or more spills from			Probability (% chance) of one or more spills
	(Bbbl)	platforms	pipelines	tankers	(total)	platforms	pipelines	tankers	(total)
Proposed Actions									
Western (Low Estimate)	0.136	0.01	0.05	0.00	0.05	1	5	n	5
Central (Low Estimate)	0.276	0.01	0.09	0.00	0.11	1	9	n	10
Western (High Estimate)	0.262	0.01	0.09	0.00	0.10	1	9	n	10
Central (High Estimate)	0.654	0.03	0.22	0.00	0.26	3	20	n	23
OCS Program									
Western (Low Estimate)	3.35	0.17	1.14	0.00	1.31	15	68	n	73
Central (Low Estimate)	12.00	0.60	4.08	0.00	4.68	45	98	n	99
Eastern (Low Estimate)	0.13	0.01	0.05	0.00	0.05	1	5	n	5
Gulfwide (Low Estimate)	15.49	0.77	5.23	0.00	6.00	54	99	n	**
Western (High Estimate)	5.53	0.28	1.77	0.08	2.13	24	83	8	88
Central (High Estimate)	16.52	0.83	5.30	0.24	6.36	56	99	21	**
Eastern (High Estimate)	0.37	0.02	0.13	0.00	0.14	2	12	n	13
Gulfwide (High Estimate)	22.42	1.13	7.24	0.32	8.69	68	**	28	**

Note: Bbbl = billion barrels; n = less than 0.5%; ** = greater than 99.5%.
"Platforms" refers to facilities used in exploration, development, or production.

Table 2. Probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 barrels occurring from a proposed action in the **Central GOM Planning Area** and contacting certain **offshore** environmental resource locations within 10 days for low and high oil resource estimates

Offshore Environmental Resource Locations	Low Estimate		High Estimate	
	prob	mean	prob	mean
Texas State Offshore Waters	1	0.01	1	0.01
7 1/2 Fathoms	n	0.00	n	0.00
Flower Gardens Banks	n	0.00	1	0.01
Stetson Bank	n	0.00	n	0.00
Alabama State Offshore Waters	n	0.00	n	0.00
Louisiana (Eastern) State Offshore Waters	2	0.02	4	0.04
Louisiana (Western) State Offshore Waters	9	0.10	19	0.20
Mississippi State Offshore Waters	n	0.00	n	0.00
Chandeleur Islands	1	0.01	2	0.02
Sonnier Bank	1	0.01	2	0.02
Florida Panhandle State Offshore Waters	n	0.00	n	0.00
Florida Peninsula State Offshore Waters	n	0.00	n	0.00
Big Bend Seagrass	n	0.00	n	0.00
Florida Middle Ground	n	0.00	n	0.00
Florda Keys National Marine Sanctuary	n	0.00	n	0.00
Tortugas Ecological Reserve	n	0.00	n	0.00
Boundary Target 1	n	0.00	n	0.00
Boundary Target 2	n	0.00	n	0.00
Boundary Target 3	n	0.00	n	0.00
Boundary Target 4	n	0.00	n	0.00
North Florida Straits	n	0.00	n	0.00
South Florida Straits	n	0.00	n	0.00
Mexican Waters	n	0.00	n	0.00

Notes: ** = Greater than 99.5%; n = less than 0.5%

Table 3a. Probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 barrels occurring from a proposed action in the **Central GOM Planning Area** and contacting certain **onshore** environmental resource habitats, recreational beaches, or Texas county shorelines within 10 days for low and high oil resource estimates

Onshore Environmental Resource Habitats, Recreational Beaches, Texas County Shorelines	Low Estimate		High Estimate	
	prob	mean	prob	mean
Diving Bird Habitat	4	0.04	9	0.09
Gull, Tern & Charadriid Allies Habitat	7	0.08	15	0.17
Raptor Bird Habitat	1	0.01	2	0.02
Charadriid Shorebird Habitat	7	0.08	15	0.17
Wading Bird Habitat	5	0.05	11	0.12
Waterfowl Habitat	9	0.09	18	0.19
Snowy Plover Habitat	2	0.02	4	0.04
Brown Pelican Habitat	4	0.04	8	0.09
Whooping Crane Habitat	n	0.00	n	0.00
Bald Eagle Habitat	7	0.07	14	0.15
Piping Plover	7	0.07	14	0.15
Gulf Sturgeon Known Shoreline Locations	2	0.02	5	0.05
Alabama Beach Mouse Habitat	n	0.00	n	0.00
Choctawhatchee Beach Mouse Habitat	n	0.00	n	0.00
Perdido Key Beach Mouse Habitat	n	0.00	n	0.00
St. Andrew Beach Mouse Habitat	n	0.00	n	0.00
TX Coastal Bend Area Beaches	n	0.00	n	0.00
TX Matagorda Area Beaches	n	0.00	n	0.00
TX Galveston Area Beaches	n	0.00	n	0.00
TX Sea Rim State Park	n	0.00	n	0.00
LA Beaches	2	0.02	4	0.04
AL/MS Gulf Islands	n	0.00	n	0.00
AL Gulf Shores	n	0.00	n	0.00
FL Panhandle Beaches	n	0.00	n	0.00
Fl Big Bend Beaches	n	0.00	n	0.00
FL Southwest Beaches	n	0.00	n	0.00
FL Ten Thousand Islands	n	0.00	n	0.00
Cameron, TX	n	0.00	n	0.00
Willacy, TX	n	0.00	n	0.00
Kenedy, TX	n	0.00	n	0.00
Kleberg, TX	n	0.00	n	0.00
Nueces, TX	n	0.00	n	0.00
Aransas, TX	n	0.00	n	0.00
Calhoun, TX	n	0.00	n	0.00
Matagorda, TX	n	0.00	n	0.00
Brazoria, TX	n	0.00	n	0.00
Galveston, TX	n	0.00	n	0.00
Chambers, TX	n	0.00	n	0.00
Jefferson, TX	n	0.00	n	0.00

Notes: ** = Greater than 99.5%; n = less than 0.5%

Table 3b. Probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 barrels occurring from a proposed action in the **Central GOM Planning Area** and contacting the shoreline of Louisiana parishes or Mississippi, Alabama, and Florida counties within 10 days for low and high oil resource estimates—Continued

Parish or County Shoreline	Low Estimate		High Estimate	
	prob	mean	prob	mean
Cameron, LA	1	0.01	2	0.02
Vermilion, LA	1	0.01	1	0.01
Iberia, LA	n	0.00	n	0.00
St. Mary, LA	n	0.00	n	0.00
Terrebonne, LA	1	0.01	2	0.02
Lafourche, LA	1	0.01	3	0.03
Jefferson, LA	n	0.00	1	0.01
Plaquemines, LA	4	0.04	8	0.08
St. Bernard, LA	n	0.00	n	0.00
Hancock, MS	n	0.00	n	0.00
Harrison, MS	n	0.00	n	0.00
Jackson, MS	n	0.00	n	0.00
Mobile, AL	n	0.00	n	0.00
Badwin, AL	n	0.00	n	0.00
Escambia, FL	n	0.00	n	0.00
Santa Rosa, FL	n	0.00	n	0.00
Okaloosa, FL	n	0.00	n	0.00
Walton, FL	n	0.00	n	0.00
Bay, FL	n	0.00	n	0.00
Gulf, FL	n	0.00	n	0.00
Franklin, FL	n	0.00	n	0.00
Wakulla, FL	n	0.00	n	0.00
Jefferson, FL	n	0.00	n	0.00
Taylor, FL	n	0.00	n	0.00
Dixie, FL	n	0.00	n	0.00
Levy, FL	n	0.00	n	0.00
Citrus, FL	n	0.00	n	0.00
Hernando, FL	n	0.00	n	0.00
Pasco, FL	n	0.00	n	0.00
Pinellas, FL	n	0.00	n	0.00
Hillsborough, FL	n	0.00	n	0.00
Manatee, FL	n	0.00	n	0.00
Sarasota, FL	n	0.00	n	0.00
Charlotte, FL	n	0.00	n	0.00
Lee, FL	n	0.00	n	0.00
Collier, FL	n	0.00	n	0.00
Monroe, FL	n	0.00	n	0.00

Notes: ** = Greater than 99.5%; n = less than 0.5%

Table 4. Probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 barrels occurring from a proposed action in the **Western GOM Planning Area** and contacting certain **offshore** environmental resource locations within 10 days for low and high oil resource estimates

Offshore Environmental Resource Locations	Low Estimate		High Estimate	
	prob	mean	prob	mean
Texas State Offshore Waters	5	0.05	8	0.09
7 1/2 Fathoms	n	0.00	n	0.00
Flower Gardens Banks	2	0.02	4	0.04
Stetson Bank	1	0.01	2	0.02
Alabama State Offshore Waters	n	0.00	n	0.00
Louisiana (Eastern) State Offshore Waters	n	0.00	n	0.00
Louisiana (Western) State Offshore Waters	1	0.01	2	0.02
Mississippi State Offshore Waters	n	0.00	n	0.00
Chandeleur Islands	n	0.00	n	0.00
Sonnier Bank	1	0.01	1	0.01
Florida Panhandle State Offshore Waters	n	0.00	n	0.00
Florida Peninsula State Offshore Waters	n	0.00	n	0.00
Big Bend Seagrass	n	0.00	n	0.00
Florida Middle Ground	n	0.00	n	0.00
Florda Keys National Marine Sanctuary	n	0.00	n	0.00
Tortugas Ecological Reserve	n	0.00	n	0.00
Boundary Target 1	n	0.00	n	0.00
Boundary Target 2	n	0.00	n	0.00
Boundary Target 3	n	0.00	n	0.00
Boundary Target 4	n	0.00	n	0.00
North Florida Straits	n	0.00	n	0.00
South Florida Straits	n	0.00	n	0.00
Mexican Waters	n	0.00	n	0.00

Notes: ** = Greater than 99.5%; n = less than 0.5%

Table 5a. Probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 barrels occurring from a proposed action in the **Western GOM Planning Area** and contacting certain **onshore** environmental resource habitats, recreational beaches, or Texas county shorelines within 10 days for low and high oil resource estimates

Onshore Environmental Resource Habitats, Recreational Beaches, Texas County Shorelines	Low Estimate		High Estimate	
	prob	mean	prob	mean
Diving Bird Habitat	4	0.04	7	0.07
Gulls, Terns & Charadriid Allies Habitat	4	0.05	8	0.08
Raptor Bird Habitat	4	0.04	7	0.07
Charadriid Shorebird Habitat	5	0.05	8	0.08
Wading Bird Habitat	4	0.04	7	0.07
Waterfowl Habitat	5	0.05	8	0.08
Snowy Plover Habitat	2	0.02	4	0.04
Brown Pelican Habitat	4	0.04	7	0.07
Whooping Crane Habitat	n	0.00	n	0.00
Bald Eagle Habitat	1	0.01	1	0.01
Piping Plover Habitat	3	0.03	6	0.06
Gulf Sturgeon Known Shoreline Locations	n	0.00	n	0.00
Alabama Beach Mouse Habitat	n	0.00	n	0.00
Choctawhatchee Beach Mouse Habitat	n	0.00	n	0.00
Perdido Key Beach Mouse Habitat	n	0.00	n	0.00
St. Andrew Beach Mouse Habitat	n	0.00	n	0.00
TX Coastal Bend Area Beaches	n	0.00	1	0.01
TX Matagorda Area Beaches	1	0.01	2	0.02
TX Galveston Area Beaches	1	0.01	2	0.02
TX Sea Rim State Park	n	0.00	n	0.00
LA Beaches	1	0.01	1	0.01
AL/MS Gulf Islands	n	0.00	n	0.00
AL Gulf Shores	n	0.00	n	0.00
FL Panhandle Beaches	n	0.00	n	0.00
FL Big Bend Beaches	n	0.00	n	0.00
FL Southwest Beaches	n	0.00	n	0.00
FL Ten Thousand Islands	n	0.00	n	0.00
Cameron, TX	n	0.00	n	0.00
Willacy, TX	n	0.00	n	0.00
Kenedy, TX	n	0.00	n	0.00
Kleberg, TX	n	0.00	n	0.00
Nueces, TX	n	0.00	n	0.00
Aransas, TX	n	0.00	n	0.00
Calhoun, TX	n	0.00	1	0.01
Matagorda, TX	1	0.01	2	0.02
Brazoria, TX	1	0.01	1	0.01
Galveston, TX	1	0.01	1	0.01
Chambers, TX	n	0.00	n	0.00
Jefferson, TX	n	0.00	1	0.01

Notes: ** = Greater than 99.5%; n = less than 0.5%

Table 5b. Probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 barrels occurring from a proposed action in the **Western GOM Planning Area** and contacting shorelines of Louisiana parishes or Mississippi, Alabama, and Florida counties within 10 days for low and high oil resource estimates—Continued

Parish or County Shoreline	Low Estimate prob	Low Estimate mean	High Estimate prob	High Estimate mean
Cameron, LA	1	0.01	1	0.01
Vermilion, LA	n	0.00	n	0.00
Iberia, LA	n	0.00	n	0.00
St. Mary, LA	n	0.00	n	0.00
Terrebonne, LA	n	0.00	n	0.00
Lafourche, LA	n	0.00	n	0.00
Jefferson, LA	n	0.00	n	0.00
Plaquemines, LA	n	0.00	n	0.00
St. Bernard, LA	n	0.00	n	0.00
Hancock, MS	n	0.00	n	0.00
Harrison, MS	n	0.00	n	0.00
Jackson, MS	n	0.00	n	0.00
Mobile, AL	n	0.00	n	0.00
Badwin, AL	n	0.00	n	0.00
Escambia, FL	n	0.00	n	0.00
Santa Rosa, FL	n	0.00	n	0.00
Okaloosa, FL	n	0.00	n	0.00
Walton, FL	n	0.00	n	0.00
Bay, FL	n	0.00	n	0.00
Gulf, FL	n	0.00	n	0.00
Franklin, FL	n	0.00	n	0.00
Wakulla, FL	n	0.00	n	0.00
Jefferson, FL	n	0.00	n	0.00
Taylor, FL	n	0.00	n	0.00
Dixie, FL	n	0.00	n	0.00
Levy, FL	n	0.00	n	0.00
Citrus, FL	n	0.00	n	0.00
Hernando, FL	n	0.00	n	0.00
Pasco, FL	n	0.00	n	0.00
Pinellas, FL	n	0.00	n	0.00
Hillsborough, FL	n	0.00	n	0.00
Manatee, FL	n	0.00	n	0.00
Sarasota, FL	n	0.00	n	0.00
Charlotte, FL	n	0.00	n	0.00
Lee, FL	n	0.00	n	0.00
Collier, FL	n	0.00	n	0.00
Monroe, FL	n	0.00	n	0.00

Notes: ** = Greater than 99.5%; n = less than 0.5%

Table 6. Probabilities (expressed as percent chance) of one or more offshore spills greater than or equal to 1,000 barrels occurring from a proposed action in the **Western or Central GOM Planning Area** and contacting certain **onshore** environmental resource habitats within 10 days for low and high oil resource estimates

	Western		Central	
Environmental Resource Habitats	Low	High	Low	High
Mexico Sea Turtle Nesting Habitat	n	n	n	n
Mexico Sea Turtle Mating Habitat	n	n	n	n
Mexico Sea Turtle General Coastal Habitat	n	n	n	n
TX Sea Turtle Nesting Habitat-Galveston Area	1	2	n	n
TX Sea Turtle Nesting Habitat-Matagorda Area	1	2	n	n
TX Sea Turtle Nesting Habitat-Coastal Bend Area	n	1	n	n
TX Sea Turtle Nesting Habitat-Sea Rim Area	n	n	n	n
TX Sea Turtle Mating Habitat	3	5	n	1
TX Sea Turtle General Coastal Habitat	5	8	1	1
LA Sea Turtle Nesting Habitat	n	n	1	1
LA Sea Turtle Mating Habitat	n	n	n	1
LA Sea Turtle General Coastal Habitat-East	n	n	2	4
LA Sea Turtle General Coastal Habitat-West	1	2	9	19
MS/AL Sea Turtle Nesting Habitat	n	n	n	n
MS Sea Turtle Mating Habitat	n	n	n	n
AL Sea Turtle Mating Habitat	n	n	n	n
MS Sea Turtle General Coastal Habitat	n	n	n	n
AL Sea Turtle General Coastal Habitat	n	n	n	n
FL Sea Turtle Nesting Habitat-Panhandle Area	n	n	n	n
FL Sea Turtle Mating Habitat-Panhandle Area	n	n	n	n
FL Sea Turtle Gen. Coast. Habitat-Panhandle Area	n	n	n	n
FL Sea Turtle Nesting Habitat-Peninsula Area	n	n	n	n
FL Sea Turtle Mating Habitat-Peninsula Area	n	n	n	n
FL Sea Turtle General Coastal Habitat-Pen. Area	n	n	n	n
FL Sea Turtle Nesting Habitat-Tortugas Area	n	n	n	n
FL Sea Turtle Mating Habitat-Tortugas Area	n	n	n	n
FL Sea Turtle Gen. Coastal Habitat-Tortugas Area	n	n	n	n
FL Sea Turtle Nesting Habitat-Keys Area	n	n	n	n
FL Sea Turtle Mating Habitat-Keys Area	n	n	n	n
FL Sea Turtle General Coastal Habitat-Keys Area	n	n	n	n
Mexico Marine Mammal Habitat	n	n	n	n
TX Marine Mammal Habitat	5	8	1	1
LA West Marine Mammal Habitat	1	2	9	19
LA East Marine Mammal Habitat	n	n	2	4
MS Marine Mammal Habitat	n	n	n	n
AL Marine Mammal Habitat	n	n	n	n
FL Panhandle Marine Mammal Habitat	n	n	n	n
FL Peninsula Marine Mammal Habitat	n	n	n	n
FL Tortugas Marine Mammal Habitat	n	n	n	n
LA/MS/AL Manatee Area (Apr-Nov)	n	n	n	1
FL Panhandle Manatees Areas (Apr-Nov)	n	n	n	n
FL Panhandle Manatees Areas (Dec-Mar)	n	n	n	n
FL Big Bend Manatees Areas (Apr-Nov)	n	n	n	n
FL Big Bend Manatees Areas (Dec-Mar)	n	n	n	n
FL Southwest Manatees Areas (Apr-Nov)	n	n	n	n
FL Southwest Manatees Areas (Dec-Mar)	n	n	n	n
FL Ten Thousand Islands Manatees Areas (Apr-Nov)	n	n	n	n
FL Ten Thousand Islands Manatees Areas (Dec-Mar)	n	n	n	n

Notes: ** = Greater than 99.5%; n = less than 0.5%

The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection

20 Years of Service to America
MMS
Minerals Management Service
1982-2002